Pear Pest Management Alliance Report

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Lead Persons

Chris Zanobini
Executive Director
California Pear Advisory Board

Bob McClain
Research Coordinator
California Pear Advisory Board

Submitting Organizations

California Pear Advisory Board — Lead Agency
Chris Zanobini, Executive Director
1521 "I" Street
Sacramento, CA 95814-2016
Phone: (916) 441-0432
Fax: (916) 446-1063

Pear Pest Management Research Fund

Terry Barton, President
California Pear Growers
1220 Melody Lane, Suite 160
Roseville, CA 95678-5181
Phone: (916) 774-9550
Fax: (916) 774-9552

Pat McCaa
Del Monte Foods
PO Box 30190
Stockton, CA 95213-0190
Phone: (209) 467-3715
Fax: (209) 941-4438

Jerry Cordy, Chair
Pacific Coast Producers
PO Box 1015
Walnut Grove, CA 95690-1015
Phone: (916) 776-2178
Fax: (916) 776-3958

Brad Lawley
Tri Valley Growers
3200 E. Eight Mile Rd.
Stockton, CA 95212-9414
Phone: (209) 931-8038
Fax: (209) 369-2333

California Pear Growers
Terry Barton, President

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ACKNOWLEDGEMENTS

Researchers

Steven Welter
Insect Biology
College of Natural Resources
University of California
201 Wellman Hall
Berkeley, CA 94720-3112
Phone: (510) 642-2355
Fax: (510) 642-0477

Bob Van Steenwyk
Insect Biology
College of Natural Resources
University of California
201 Wellman Hall
Berkeley, CA 94720-3112
Phone: (510) 643-5159
Fax: (510) 642-4879

Steven Lindow
Plant & Microbial Biology
College of Natural Resources
University of California
111 Koshland Hall
Berkeley, CA 94720-3102
Phone: (510) 642-4174
Fax: (510) 643-5098

Lucia Varela
North Coast IPM Advisor
UCCE Sonoma County
2604 Ventura Ave., Rm. 100
Santa Rosa, CA 95403-2894
Phone: (707) 527-2601
Fax: (707) 527-2623

UC Extension Personnel:

Rachel Elkins
UCCE Lake, Mendocino,
Yuba & Sutter Counties
883 Lakeport Blvd.
Lakeport, CA 95453-5405
Phone: (707) 263-6838
Fax: (707) 263-3963

Chuck Ingels
UCCE Sacramento County
4145 Branch Center Rd.
Sacramento, CA 95827-3898
Phone: (916) 875-6913
Fax: (916) 875-6233

Mario Moratorio
Temporary North Coast IPM
UCCE El Dorado County
311 Fair Lane
Placerville, CA 95667-4104
Phone: (707) 527-2601
Fax: (707) 527-2623

Beth Mitcham
UC Pear Liaison
Department of Pomology
University of California
1045 Wickson Hall
Davis, CA 95616-8683
Phone: (530) 752-7512
Fax: (530) 752-8502

Acknowledgements, cont.

Pest Control Advisors

Pete Chevalier, President
Ukiah Valley IPM Pear Growers, Inc.
United Agri-Products, Manager
201 Thomas Street
Ukiah, CA 95482
Phone: 707-462-0597
Fax: 707-462-0590

Jim Dahlberg/Bob Castanho/
Brad Van Loben Sels
Harvey Lyman Co.
PO Box 276
Walnut Grove, CA 95690-0276
Phone: (916) 776-1744
Fax: (916) 776-1031

Bill Oldham, PCA
Oldham Farms
2195 Gowan Way
Redwood Valley, CA 95470-9557
Phone: (707) 485-1023
Fax: (707) 485-1023

Thom Wiseman/Karl Yuki
John Taylor Fertilizer Co.
4707 Twin Cities Rd.
Elk Grove, CA 95758-9730
Phone: (916) 776-2113
Fax: (916) 776-2021

Broc Zoller, PCA
The Pear Doctor
PO Box 335
Kelseyville, CA 95451-0335
Phone: (707) 279-9773
Fax: (707) 279-9808

Randy Hansen/ Pat Weddle, PCAs
Weddle, Hansen & Assoc.
PO Box 529
Placerville, CA 95667-0529
Phone: Randy (530) 626-9696
Phone: Pat (530) 622-9061
Fax: Randy (530) 626-6801
Fax: Pat (530) 621-3213

Bill Knispel
United Agri-Products, Manager
PO Box 338
Kelseyville, CA 95451-0338
Phone: (707) 279-1553
Fax: (707) 279-8616

John Sisevich/ Neal McCoster
Harvey Lyman AgService
2532 Big Valley Rd.
Lakeport, CA 95453-9621
Phone: (707) 279-4654
Fax: (707) 279-9345

Participating Growers

Participating Growers are listed on each individual project from each pear growing district or County. Table of Contents

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ABSTRACT

The codling moth (CM) is the key insect pest of pears, with annual control costs of approximately $150.00/acre. Control of CM in pears has relied on repeated applications of organophosphate (OP) insecticides which has resulted in the outbreak of a number of secondary pests, such as pear psylla and spider mites, which require additional insecticides for their control. Also, repeated use of insecticides has resulted in the development of CM resistance to OP and cross-resistance to most alternative insecticides.

All OP insecticides will be affected by the implementation of the Food Quality Protection Act of 1996, and their future use will be severely restricted.

Alternative CM control techniques must be implemented in the near future to maintain an economically viable pear industry. One technique recently implemented has been pheromone mating disruption of CM. This is the technique of using inundative releases of the female codling moth's sex attractant to confuse male moths who cannot find the female in order to mate. In the Randall Island Pear Project, CM was successfully suppressed for five years on 760 acres with pheromone mating disruption, and, consequently, OP insecticide use was reduced by about 75%.

Adoption of mating disruption requires an increase in the information base for growers because of the novelty of the approach, the increased rates of required monitoring, and the potential for pest outbreaks normally not found in OP-dominated systems. Until growers develop confidence in these new techniques, they will continue to perceive them as highly risky. This perception sometimes hampers implementation even more than the biological or economic constraints.

<u>Work Plan Goals Met:</u>

1) Implement mating disruption with growers previously using conventional insecticide programs in four pear growing regions.
2) All regions will differ in their approach to mating disruption because of geography and insect phonology.
3) Reduced the use of organophosphate (OP) insecticides by 60%.
4) Research into secondary pests that currently act as deterrents to implementation of pheromone disruption.
5) Research into fireblight disease using a recently developed biological pesticide.

EXECUTIVE SUMMARY

The overall project focus is to establish and/or expand codling moth pheromone based reduced risk pest management projects in each of four pear-growing counties--- Sacramento, Eldorado, Lake and Mendocino. The major goal was to reduce organophosphate (OP) pesticide usage by 60% the first year. A research component would evaluate new insecticides for true bug and leafroller control, because a decrease in (OP) usage has lead to an increase in damage from these secondary pests. Secondary pest pressure has become an impediment to expansion of these projects. Additionally, in Yuba County, a demonstration project was conducted to show the biological control agent, Blight Ban A506® could be effective at half the label rate and still allow antibiotic use to be reduced by 50 – 60% for fireblight control. Total amount of the Grant is $100,000

Total budget for Sacramento County was $29,201 used for traps and monitoring costs for ten growers using five Pest Control Advisors (PCAs) participating in a CM pheromone mating disruption project which resulted in 66 to 75% reduction in OP use. Sacramento County Farm Advisor Chuck Ingels provided oversight.

In El Dorado County the pheromone project budget was $4,000 and consisted of three growers and one PCA. Because of high CM populations, small orchard size and hilly conditions, which are not conducive to pheromone dispersion, OP usage was only slightly lower than non-mating disruption orchards. Although, one grower reduced the number of OP applications by half. Chuck Ingels, UCCE Sacramento provided oversight working with Randy Hansen, the local PCA.

The Mendocino County project budgeted at $20,000 consisted of fifteen growers and two PCAs with over 1050 acres of pears. OP usage was reduced by 95%. The growers formed a nonprofit organization, the Ukiah Valley IPM Growers. Farm Advisor Mario Moritorio and North Coast IPM Advisor Lucia Varela provided project oversight.

In Lake County, the latest pear-growing district in California (harvest in late August and early September), CM populations are traditionally high due to pears remaining on the tree longer and providing a host for what becomes a large overwintering population. Thus, the term "Late Hanging." This refers to one hanging of pheromone ties in early June after one OP application. This has had the effect of managing the CM population during the critical harvest period providing for a reduced risk situation (non OP pesticide at harvest) and reducing the overwintering population for the following year. The five participating growers significantly reduced OP use by 61%. The Lake County budget was $19,845 with oversight provided by Farm Advisor Rachel Elkins

In Yuba County Rachel Elkins and Dr. Steve Lindow, UC Berkeley, conducted a demonstration project using half the rate of the biological control agent Blight Van A506® and successfully reduced the number of antibiotic applications by 66%. Budget: $3,750.

Dr. Bob Van Steenwyk from UC Berkeley, Mario Moritorio and Rachel Elkins conducted timing trials under an Experimental Use Permit of the reduced risk pesticide Confirm® used for control of leafrollers, an important secondary pest in CM pheromone disrupted orchards. Van Steenwyk also conducted trials of new reduced risk pesticides for the control of True Bugs, another important secondary pest. Total Budget: $23,255.

In the demonstration projects growers and PCAs were appraised of insect populations on a weekly basis by fax (sooner if necessary) from project leaders along with personal contacts with PCAs at weekly breakfast meetings. End of year meetings with all participants were held as well as presentations in the Early (Walnut Grove) and Late (Ukiah) District of all pear research including the Alliance projects. As of March 2000 project leaders have met with PCAs and grower participants to finalize plans for the 2000 season. They will be expanding upon the number of growers and acreage base established in 1999.

PEAR PEST MANAGEMENT ALLIANCE PROJECT FOR THE SACRAMENTO RIVER DISTRICT

Chuck Ingels
Farm Advisor, UC Cooperative Extension, Sacramento County

Cooperating Personnel

Field assistants: Anne and Wayne Larson

UC: Robert Van Steenwyk and Stephen Welter, Insect Biology Program, UC Berkeley

Participating Growers: Wally Chan, Dave Elliot Jr., Mark Mamboise, Gary Martinez, Jeff McCormack, Malcolm McCormack, Ed McDowell, Beth Robbins, Judy Smith, Bruce Wilcox

PCAs: Bob Castanho and Jim Dahlberg, Harvey Lyman Co., Walnut Grove
Duncan Smith, Western Farm Service, Walnut Grove
Thom Wiseman and Karl Yuki, John Taylor Fertilizers, Elk Grove

ABSTRACT

In this project, we set out to assist in the insect and mite monitoring for 10 growers who had not yet used mating disruption. Most growers applied pheromone dispensers at a rate of 400 per acre in April, and most used a single application of organophosphate (OP) insecticide. Very few codling moths (CM) were found the entire season. CM damage was zero at both harvests in all blocks. Obliquebanded leafroller (OBLR) moths were much more numerous, but damage was minimal in most blocks. Pear psylla and European red mite populations were very low through the season. Because these growers typically used 3 to 4 OP applications in previous years (although this year fewer cover sprays might have been applied due to very low CM populations), mating disruption led to a 66 to 75 percent reduction in OP use.

BACKGROUND

The mating disruption practices used in the Pear Pest Management Alliance project in the Sacramento River District are based on methods developed from 1993-98 in the Randall Island Project. The primary strategy in this district is to apply pheromone dispensers at a rate of 400 per acre during the period of the first codling moth (CM) biofix, in combination with reduced applications of organophosphate (OP) insecticides – usually one application.

The purpose of the Sacramento River District Project was to extend the documented practices of pheromone mating disruption to 10 pear growers who have not used mating disruption. Previous results indicate about a 70 to 75 percent reduction in usage of OP insecticides in this district compared to conventional production (often from 3 or 4 cover sprays to one). In addition, in-season sprays for mites and psylla are eliminated in some mating disrupted orchards because biological control can be enhanced. Mating disruption is often somewhat more expensive than solely using cover sprays, at least initially. But eliminating mite or psylla applications, if possible, can make this approach more economical. Furthermore, with the loss of Penncap-M and increased restrictions on the use of Guthion, the most viable long-term CM strategy is mating disruption and limited applications of Guthion or Imidan. Mating disruption usually results in declining CM populations over time. Also, reduced OP applications help reduce the buildup of resistance.

METHODS

Implementation of mating disruption. Program implementation is similar to that of the Randall Island Project. The initial goal was to assist with the insect monitoring for 10 growers who have not used codling moth mating disruption before, or who have used it only on a limited basis. However, two growers decided not to participate because of concerns about increased costs in the first year. As a result, three neighboring growers did not participate, and we were only able to find eight growers who had not used mating disruption. Therefore, we included two growers who had been using mating disruption for several years.

The size of the committed orchards was generally 30 acres, although two growers committed blocks of 20 acres. In most cases, Isomate C+ dispensers were applied at 400 per acre in April; two growers decided to use fewer than 400. An OP insecticide spray was applied at either the "A" or the "B" peak of the first CM generation.

Approach to monitoring of key insects. Codling moth populations were monitored with traps using lures of three different concentrations of pheromone, so three traps of each lure strength were hung in each orchard. Traps with 10 mg lures were the primary means of evaluating the codling moth populations. Traps with 1 and 5 mg lures were used to determine if the rate of pheromone release from the dispensers used in the mating disruption declined during the season, such that moths could identify the lower strength lure. The traps were placed at edge and interior portions of the orchard with consideration given to high-pressure areas as previously noted by the grower or the PCA. Sixteen of the trap sites were considered to be edge sites and 12 trap sites were considered to be interior sites. Specific placement of the traps included:

- 10 mg traps at the top of the tree
- 5 mg traps in the top of a tree that was about six trees away from the 10 mg trap
- 1 mg traps in the lower half of a tree about six trees away from other traps

The timing for the placement of the traps in eight of the orchards was as follows:

- 1 mg traps were set March 8 in order to detect emergence of adults;
- 5 mg and 10 mg traps were set April 19, just after dispensers were applied.

Traps were placed in the remaining two orchards on April 19 and May 4. The 5 and 10 mg lures were changed every 2 weeks; 1 mg lures were changed monthly. CM traps were monitored weekly from before biofix to harvest. Postharvest monitoring was biweekly until removal of the traps on August 16. Monitoring updates were sent to all grower and PCA cooperators each week.

Obliquebanded leaf rollers (OBLR) were monitored using 3 traps per 30-acre block and 2 traps per 20-acre block with traps being placed in the tops of the trees. Most traps were set in early March, and lures were replaced every 2 weeks. Traps were monitored on a weekly basis from placement to harvest. Postharvest monitoring was biweekly until removal on August 16.

European red mites were monitored several times during the season. The first sampling was early March; 30 buds were collected from 3 different locations within each block. These buds were examined under the microscope for the presence of mites and mite eggs. The second sampling was in early May 4 in which 30 fruit clusters were examined from 3 different locations within each block. Mid-season monitoring for mites was done every 2 weeks by collecting 100 leaves from throughout the canopy in each block; the leaves were then put through a mite-brushing machine and mites were counted using a dissecting scope.

Pear psylla was monitored early in the season by using a beating tray. Additionally, fruit clusters were examined in May using a hand lens. For mid-season psylla evaluations, one topshoot per block was examined biweekly from the tops of each of 20 trees per block.

Green fruitworm and OBLR damage were evaluated weekly from early April to late May by examining leaves and clusters. Any worms found were sent to the lab for ID.

Beneficial insects were monitored weekly through the season by using beating trays, hand lens examination, and general observation of the environment during site visits.

Fruit sampling was done in June at about 1,000-degree days. In addition, 1,000 fruit per orchard were examined in bins during both harvests. The fruit was examined for evidence of damage by codling moth, leafrollers and green fruitworm.

RESULTS

Codling moth infestation patterns were atypical when compared to recent years. The 10 and 5 mg trap counts indicated an extremely low population in the trial blocks (Fig. 1), and only 2 moths were caught in 1 mg traps all season (data not shown). There were no easily distinguishable flights during the season. Codling moth damage was zero at both harvests in all blocks. Probable reasons for the low infestation are that the overwintering population was low because of low populations the previous season and because the spring and early summer of 1999 were unusually cool.

Although OBLR trap catches were high at times (Fig. 2), fruit damage was generally low. Most blocks had very low or no infestation whereas others had some problem areas. One orchard had OBLR damage and one orchard had some green fruitworm damage (Fig. 3).

Pear psylla and European red mite counts were generally very low (data not shown), which is to be expected because most growers applied in-season sprays to control these pests. Very few or no psylla were found in the fruit clusters during May sampling. Similarly, topshoots had a total of only 6 psylla nymphs among all growers through the summer until the Aug. 9, when three orchards had 4 to 6 psylla each in the 20-topshoot sampling. No mites were found in any orchard until 21 adults and 100 eggs were found in one orchard on Aug. 9.

Other pest damage. A problem observed in the Sacramento River area during the past several years and identified within the trial blocks was confirmed as Campylomma verbasci. Symptoms include a scalloping of new leaves with a light green-grey appearance to leaves. During the early season (late April) beating tray sampling, campylomma nymphs were observed. They did not appear to cause any economic harm and they are known to be an effective predator of pear psylla.

OP Insecticide Usage. Eight of the growers used only one OP application, and one of these growers also treated the borders (Table 1). The two growers who have used mating disruption for several years did not use any OP cover sprays because of low CM populations, but they both used Bacillus thuringiensis (Bt) for OBLR control. Most growers used 3 to 4 OP sprays in past years before mating disruption was implemented. Therefore, mating disruption this year resulted in a 66 to 75 percent reduction in OP usage. It should be noted that if CM populations were high in the first year of mating disruption, two sprays might be warranted.

Figure 1. Average Number of Codling Moths per Trap (All Growers)

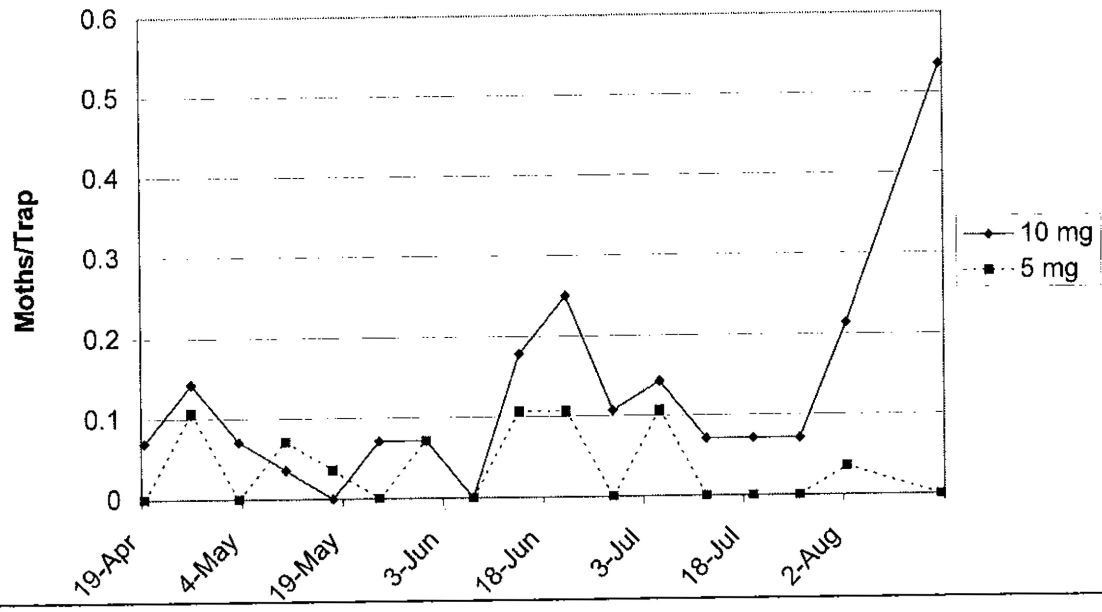


Figure 2. Average Number of OBLR Moths per Trap (All Growers)

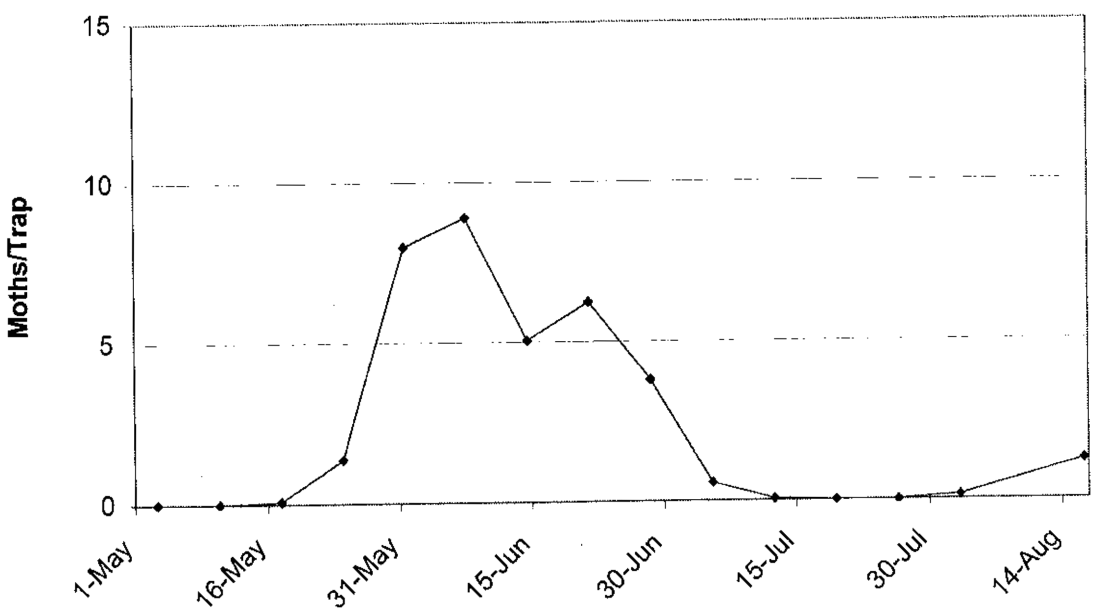


Figure 3. Fruit Damage at Harvest

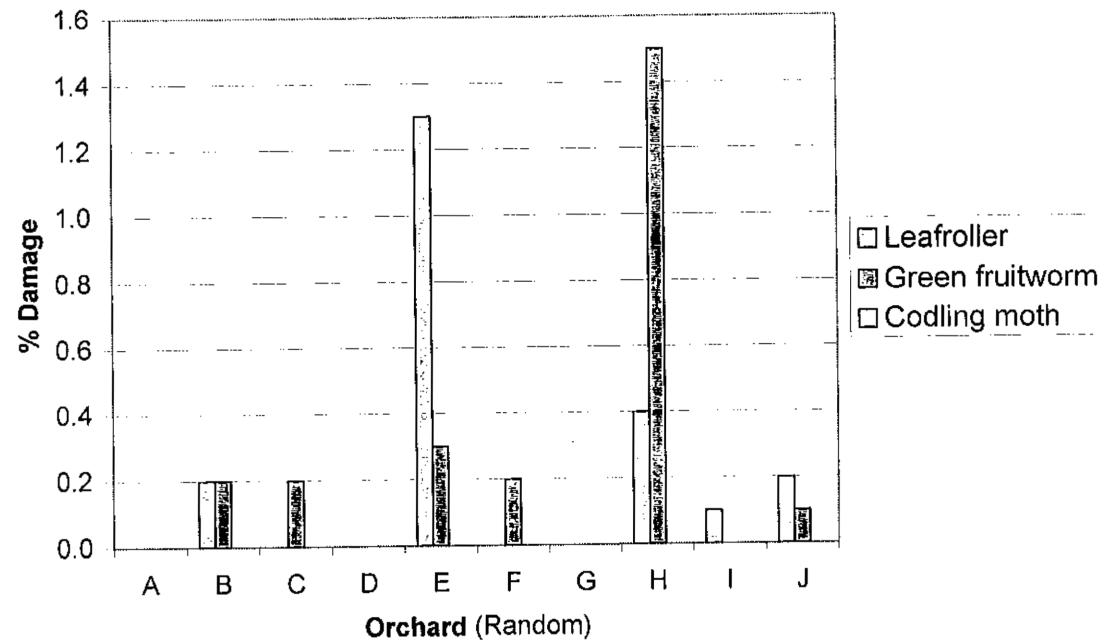


Table 1. Insecticide Usage for Codling Moth and OBLR in 1999

Grower (alphab.)	CM/OBLR Insecticide Used	Time of Application	Rate of Application Per Acre	No. of OP Applics. in Most Years (Non-MD)
Wally Chan – Home Ranch	Penncap-M	June 7	7.5 pts.	3
David Elliott Jr. – Sutter block	Dipel DF	Early July	1 lb.	All MD
M. Mamboise – Reid Ranch	Penncap-M	June 11	6 pts.	3-4
Gary Martinez – Hiawatha Ranch	Penncap-M	June 11	6 pts.	3-4
Jeff McCormack – Glanvale Ranch	Dipel DF	Early July	1 lb.	All MD
M. McCormack – 1) Koket – 2) Collins	 Guthion Penncap-M	 June 10 June 10	 2 lbs. 6 pts.	 3-4 3-4
Ed McDowell – McDowell Farms	Penncap-M	May 15	6 pts.	4
Beth Robbins – Brown & Kahrs	Penncap-M	May 15	6 pts.	3-4
Judy Smith – Smith Ranch	Penncap-M Imidan (borders)	June 18 ?	4 pts. 6 lbs.	3 0
Bruce Wilcox – Shop Ranch	Penncap-M	May 11	6 pts.	4

PEAR PEST MANAGEMENT ALLIANCE PROJECT FOR EL DORADO COUNTY

Randy Hansen, Pest Control Adviser, Weddle, Hansen & Associates, Placerville
and
Chuck Ingels, Farm Advisor, UC Cooperative Extension, Sacramento County

Cooperating Personnel
Field Assistant: Betty Ann Beauchamp
Participating Growers: Byron Sher, Pat O'Halloran, and Bob Witters

ABSTRACT

In this project, three pear growers used codling moth mating disruption who had not done so before. Large numbers of codling moth were caught in the 10 mg traps, and fewer but still large numbers were caught in 5 mg traps. Even the 1 mg traps caught substantial numbers. OBLR trap catches were also very high. Although fewer OP applications were applied in general, the high CM and OBLR populations warranted at least two cover sprays. Very little fruit damage was seen at harvest.

BACKGROUND

Most pear orchards in El Dorado County are much smaller than other pear districts, and most are on hilly terrain. This combination makes mating disruption difficult because a greater proportion of small orchards consists of edges, which are more susceptible to damage by codling moth (CM) and oblique-banded leafrollers (OBLR). Also, pheromone disperses more readily in upland portions of the orchard and tends to move down to low-lying areas, making mating disruption more difficult.

The purpose of the El Dorado Project was to extend the documented practices of pheromone mating disruption to three pear orchards in which mating disruption has not been used previously. The following pests were monitored in much the same way as in the Sacramento Pest Management Alliance project: CM, OBLR and other worms, European red mites, and pear psylla. Weekly updates were sent to all grower and PCA cooperators.

Results

CM trap catches showed at least two distinct peaks, and early season populations were especially high. Through most of the season, substantial numbers of moths were also caught in 5 mg traps, and in the first half of the season a discomforting number were also caught in 1 mg traps. This shows that pheromone levels in the orchard were probably insufficient to prevent all mating. OBLR moths were also very numerous, particularly in early and late July.

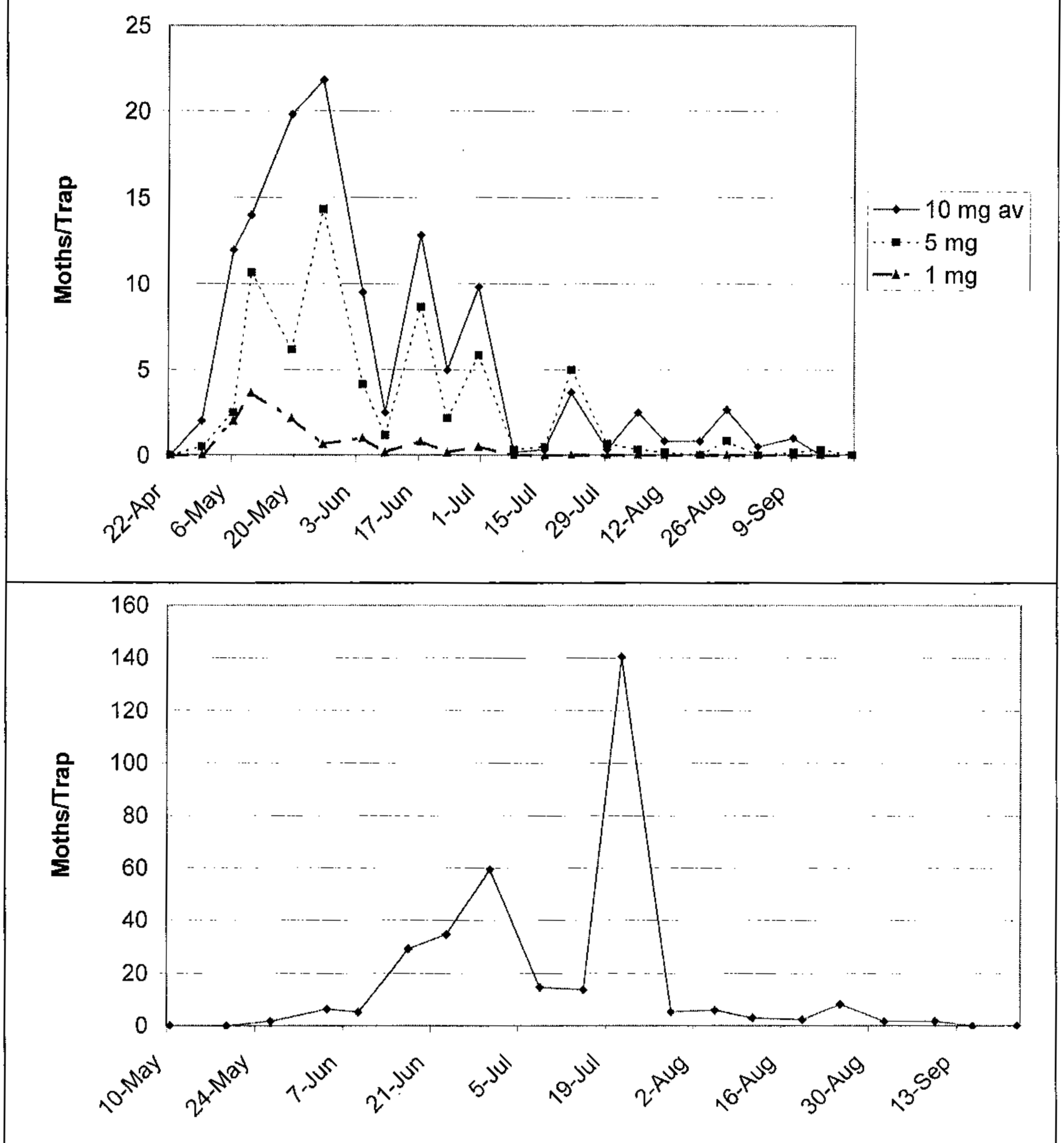
Because of the high CM and OBLR trap counts, the small orchard size, and grower comfort level, the number of OP applications was generally only slightly lower than typical non-mating disruption, although one grower cut the number of applications by half.

LBS Orchard. Mating disruption was used on half of this 12-acre orchard. The grower applied first and second cover sprays (Guthion) and applied the third spray to all but 4 rows. Preharvest CM infestation was 0.2% in the mating disrupted block and 0.7% in the non-disrupted block.

O'Halloran Orchard. This grower (6 acres) applied the first cover spray, eliminated the second (and third) spray, and applied the final spray (Imidan) to all but 4 rows. No CM damage was found in the preharvest survey of 1,000 fruit.

Witters Orchard. The first and second cover sprays (Guthion) were applied in this 6-acre orchard and the final spray was applied only on the edges. Preharvest infestation was 0.4%.

Figure 1. Average CM Moths per Trap - 1999
(All Growers)



Lucia Varela, North Coast IPM Advisor Cooperators:

Growers: Steve Giannecchini, Mike Hildreth, Wallace Hooper, Bill Johnson, Frank Johnson, Ron Ledford, Bruce Ledford, Tim Norgard, Miles Oswald, Morgan Ruddick, Chris Ruddick, Matt Ruddick, Richard Ruddick and Rick Ruddick, Randy Ruddick.

Pest Management Consultants: Pete Chevalier and Bill Oldham

ABSTRACT:
This was the fourth year of an implementation program in the Mendocino pear district aimed at facilitating and broadening the adoption of codling moth mating disruption. This year we increased the acreage under pheromone confusion by 150, for a total of 1050 acres. Organophosphate use for codling moth control was reduced by 95% from the average of three OP cover sprays per year used from 1991 to 1995 . There was a slight increase in leafroller damage. Boxelder bug damage was observed in the first 10 rows from the Russian River. This year the Ukiah Valley Pear Grower Coalition was formed to run the project

Objectives:
1) Implement areawide management of codling moth with pheromone mating disruption in Mendocino County pear orchards.
2) Estimate the impact of individual grower practices on program efficacy and reliability.
3) Implement non-disruptive controls of secondary pests and supplemental codling moth control.

INTRODUCTION
An areawide management of codling moth using mating disruption was initiated in Mendocino County in 1996 on 400 contiguous acres of pears. It increased to 550 acres in 1997 and to 900 acres in 1998 (see Table 1A and Map).

Mating disruption applied on a regional scale has provided pear and apple growers with an alternative to frequent organophosphate-based management strategies and an improvement in efficacy compared to single-farm approaches. Areawide management appears to reduce the risk associated with pesticide use and increases the ability of natural enemies to regulate populations of secondary orchard insect pests and thus provides a more sustainable and stable pest management program.

The primary insecticides used for codling moth control are the organophosphates Guthion, Penn-Cap and Imidan. All these organophosphate will be affected by the implementation of the Food Quality Protection Act of 1996. New less-disruptive chemicals must be implemented as supplemental control. As new insecticides are implemented for supplemental control in the coming year, monitoring and evaluation will become critical for the success of the program.

Successful adoption of mating disruption is based on acquiring confidence in monitoring codling moth under mating disruption and determining when further measures are needed. Predicting codling moth damage under mating disruption requires intensive monitoring and experience in assessing trap catches. Major concerns in blocks under pheromone confusion are controlling codling moth in orchard borders, the reliability of trap monitoring, and the appearance of secondary pests such as leafrollers. Organophosphate use for codling moth control was reduced by 66%, 80% and 82% in 1996 through 1998, respectively (see Table 1D). With an intensive monitoring regimen, we were able to predict and control codling moth "hot spots". There was a slight increase in leafroller damage in 1996 through 1998. Pests of increased concern were various true bugs, including boxelder, lygus and stink bugs. The greatest damage was observed in the rows adjacent to the Russian River, due to boxelder bug. Spider mite damage varies greatly among years and sites. These variations may be due to initial spider mite population levels at the beginning of the season, environmental and climatic factors, the complex of predators present and the amount of disruption that pesticides have on the system. We hypothesize that conditions under mating disruption are more favorable for integrated control of secondary pests, thus lessening the probability that the threshold levels for mite outbreaks would be exceeded. This reduced the need for insecticide applications for secondary pests will offset the higher cost of mating disruption technology. In the first three years of the project we were able to eliminate post-harvest clean-up sprays for mites.

MATERIALS AND METHODS

Pheromone mating disruption was used as the key technique for managing codling moth. One application of BioControl Isomate-C+ dispensers at a rate of 400 dispensers per acre was applied on 30% of the acreage (see Table 1B). The other 70% of the acreage received two applications of Concept Checkmate dispensers at a rate of 160 dispensers per acre.

The groundwork for implementing this project was initiated in 1996 with a combination program of mating disruption and azinphosmethyl use to reduce existing population levels. Based on this experience, no supplemental insecticide was applied in orchards with low population levels. Based on trap catches, orchards new to the project or orchards with high codling moth populations received supplemental sprays.

Program efficacy was determined by fruit evaluations twice during the growing season (preceding 2nd application of pheromone, and at harvests). Twenty-one sites were selected within the project based on 30 acres per site. Depending on the site layout, 1000 to 2000 fruit per site (10 per tree from top and bottom) were selected from each site and scored for fruit injury from both codling moth and potential secondary pests. Five percent of the fruit was cut to look for cryptic infestations. Bin samples were performed at harvest. We recorded damage made by leafrollers, stink bugs, and Lygus.

Weekly monitoring for codling moth relied on pheromone traps baited with 10 times the normal rate of pheromone and placed high in the tree canopy. Pheromones trap were placed throughout the project at a rate of 3 traps per 10 acres. Extra traps were placed at the borders of the project baited with a 1 mg codlemone lure.

A post harvest evaluation to determine the number of fruit remaining and the percent infestation was made three weeks after harvest. Thirty-six blocks were sampled. Infestation levels post-harvest give an indication of the population levels for the coming spring. Thus, it provides an early indication of the problem blocks in the following year and an indication of the effectiveness of the program. Five hundred fruit per site were cut open and examined for presence of codling moth damage. Population levels at harvest will be correlated with trap catches the following year.

RESULTS AND DISCUSSION

This year we increased the area under mating disruption by 150 acres to a total of 1050 acres (see Table 1A and Map). Organophosphate use for codling moth control was reduced by 95% assuming three cover sprays, the average number of cover sprays on orchards under organophosphate control in the Ukiah Valley in 1991 through 1995. Of the 1050 acres under pheromone confusion, 73% (770 acres) received no cover sprays, 26% (270 acres) received 1 cover spray and 1% (10 acres) received 2 cover sprays (see Table 1C). Of the acreage that received one cover spray 48% (150 acres) was new acreage into the project. New acreage coming into the project had initial high codling moth populations necessitating supplemental sprays. A first cover spray was applied where traps baited with 10X lures exceeded 10 moths/trap/week. Spays were applied only in areas where there was a consistent trap catch. In this forth year we exceeded the target of 75% reduction based on other areawide projects and the 66 to 82% reduction in our first three years (see Table 1D).

The average codling moth trap catches for the entire project were significantly lower in 1999 than those in 1998 (see Chart 1). Total trap catches decreased from 1996 to 1997. In 1998 we observed an increase in the total trap catches due to high populations in the new acreage entering the project that year (350 acres of 900, see Farm 8 and 9 in Chart 2 and Table 2). Codling moth season long cumulative trap catches decreased in all blocks (see Chart 2 and Table 2) throughout the life of the project.

We detected no codling moth damage in the fruit sampled prior to the second application of pheromone. Codling moth damage at harvest was very low. After four years in the program the problem blocks (Farm 6, block b, see Chart 2) suffered no damage at harvest. This block had a history of codling moth pressure with 8% damage at harvest in 1995 prior to starting the areawide mating disruption project. After four years the populations of codling moth in this "hot spot" block have decreased substantially and no organophosphate (OP) was used this year. Also, populations have decreased in those blocks entering the project in 1998 (see Table 2 & Chart 2).

Low levels of oblique-banded leafroller infestation (0.1 – 3.2%) were detected in 10 of the 21 sites monitored (48% of blocks sampled). This is an increase from 1996 when no damage was detected; 1997 when one block had 1% infestation; and from 1998 when 32% of the blocks sampled had less than 1% infestation and 9% of the blocks had between 1 and 5% damage. Low level leafroller damage was detected in Farm 5 and control measures were taken during the second oblique-banded leafroller flight. As in previous years Boxelder damage was restricted to the first 10 rows from the riparian area. The greatest damage was observed in the rows adjacent to the Russian River with up to 2.5% damage.

Of the 36 blocks sampled post-harvest, 27 blocks (75%) had no codling moth infestation. Seven blocks (19%) had less than 1% infestation and two blocks had 4.3 and 6% infestation respectively. Infestation levels post-harvest give an indication of the population levels for the coming spring. It provides an early indication of the problem blocks in the coming year and an indication of the effectiveness of the program. Percent infestation less than 1% is not of concern, greater than 5% is of concern and between 1 and 5% should be monitored carefully in the coming year. Population levels at harvest will be correlated with trap catches the following year.

Table 1 - Mendocino areawide pheromone *mating* disruption project description (1996-1998)

A) Acres under codling moth mating disruption

	1996	1997	1998	1999
Acres	400	550	900	1050

B) Pheromone dispensers applied

	Ties/acre				
	1996	1997	1998	1999	1999
	Isomate-C+	Isomate-C+	Isomate-C+	Isomate-C+[2]	Checkmate[3]
At biofix	400	400	400	400	160
At 900 dd	400	200	200[1]		160

[1] In 550 acres (350 acres received only one application at biofix)
[2] In 30% of the acreage (310 acres)
[3] In 70% of the acreage (740 acres)

C) Supplemental organophosphate cover sprays

	% total acreage (No. acres)							
	1996		1997		1998		1999	
No spray			66	(360)	61	(552)	73	(770)
1 spray	70	(282)	16	(90)	22	(196)	26	(270)
2 sprays	17	(68)	18	(100)	17	(152)	1	(10)
3 sprays	5	(20)						
4 sprays	8	(30)						

D) Percent Organophosphate reduction

	1996	1997	1998	1999
% OP reduction	66	80	82	95

Table 2 - Cumulative codling moth male trap catches (1996-1999)

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9
1996	1.87	2.07	4.82	n/a	17.49	26.29	n/a	n/a	n/a
1997	1.62	4.49	3.22	n/a	13.37	10.86	16.03	n/a	n/a
1998	7.65	5.62	4.32	4.83	5.66	8.27	7.20	32.93	11.22
1999	3.88	2.20	3.09	1.86	3.06	5.74	5.23	18.80	7.33

Chart 1 - 1996-1999 Male Codling moth weekly trap catches

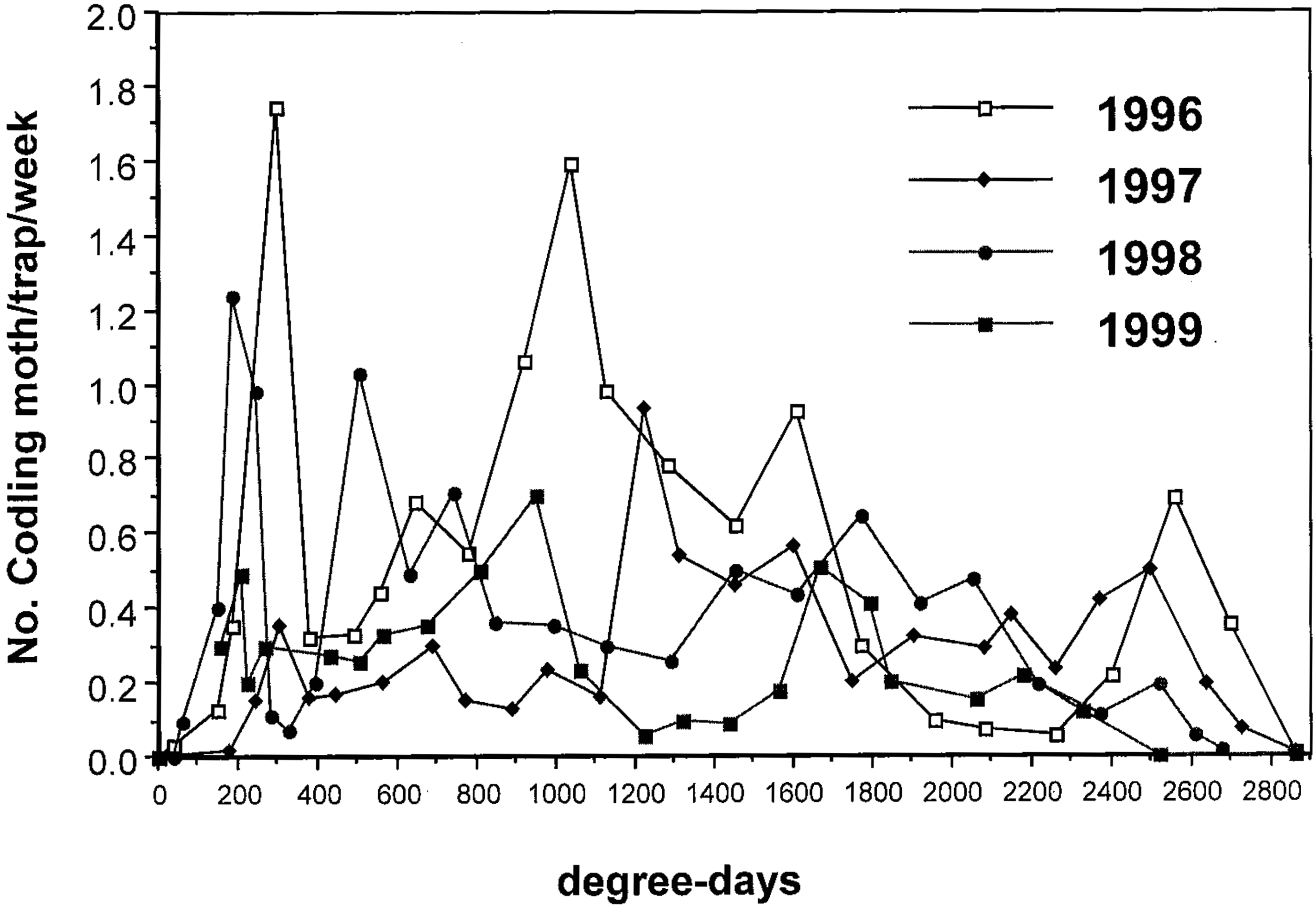
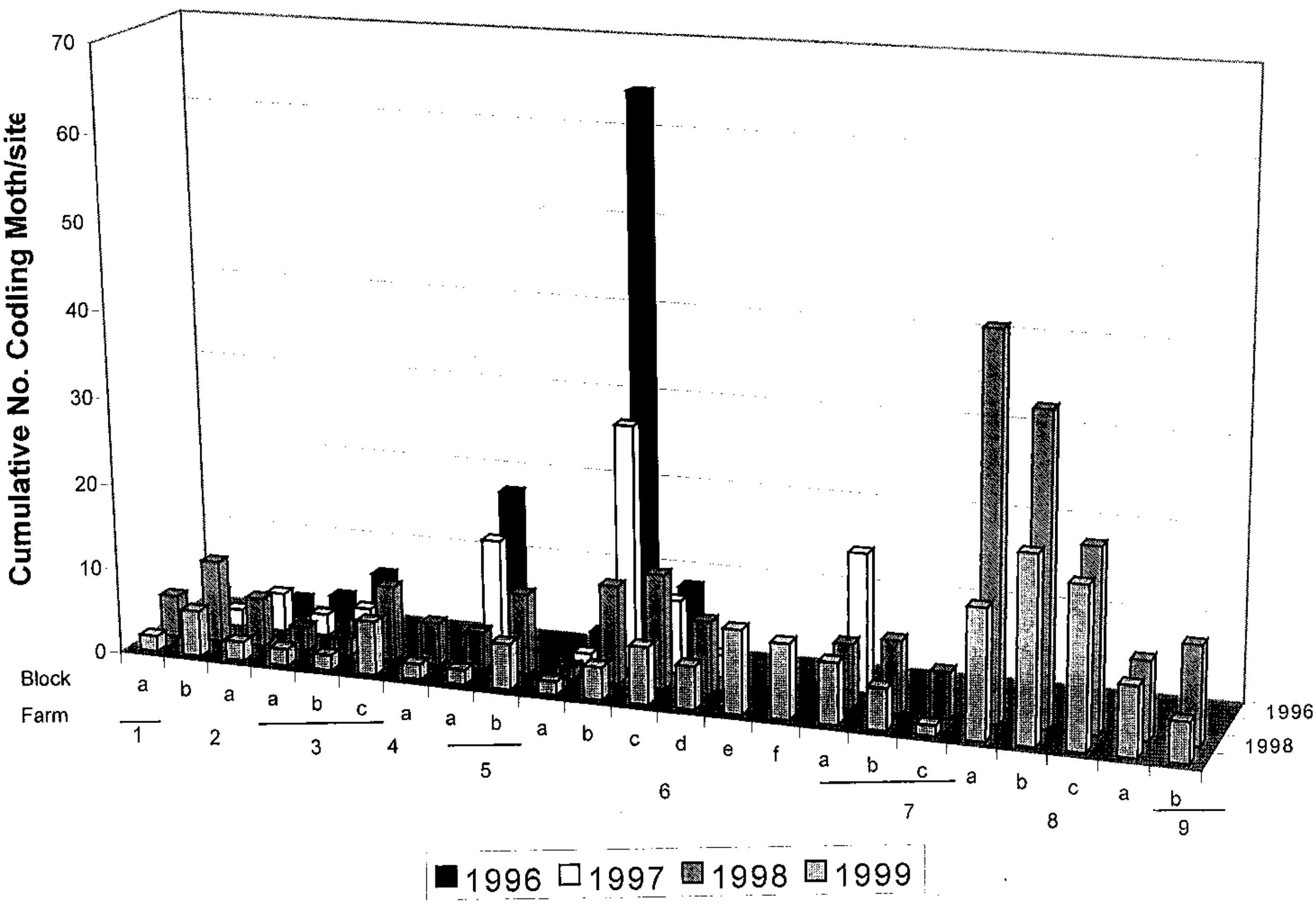
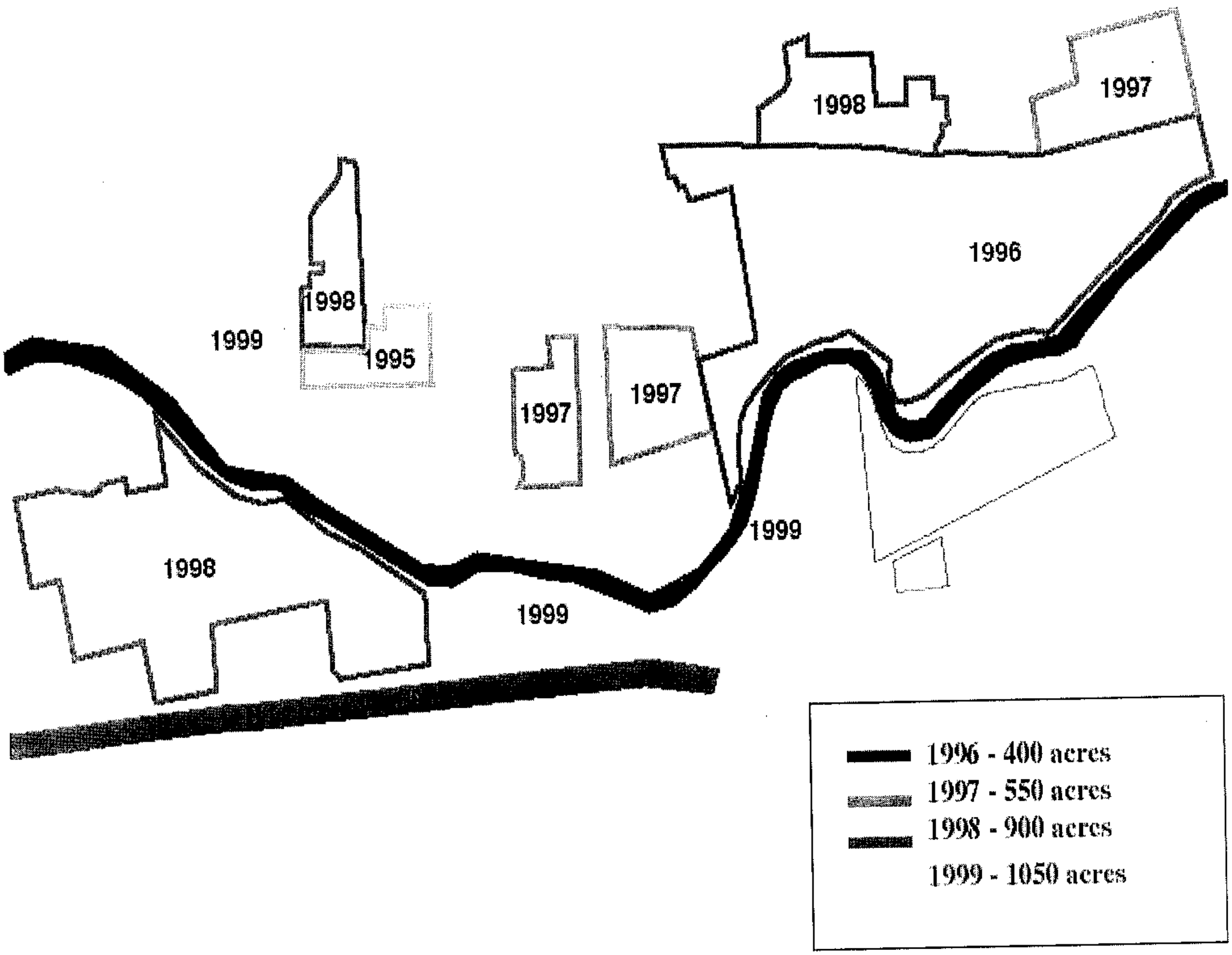


Chart 2 - 1996-1999 Male Codling moth cumulative trap catches by block in each of 9 farms



Mendocino Codling Moth Mating Disruption Project



LATE-SEASON PHEROMONE HANGING TO REDUCE OVERWINTERING CODLING MOTH POPULATIONS IN LAKE COUNTY PEAR ORCHARDS

Report submitted for the Pear Pest Management Alliance

Project Leader: Rachel Elkins
U.C. Cooperative Extension
Lake County

Collaborators: Pete Chevalier, Greg McCosker, Bill Oldham, John Sisevich, and Broc Zoller

Research Assistants: Misty Barker, Jim Benson, Dustin Blakey, Sarah Davis, Jim Gonzales, Erin Ruddick, Marianne Seidler, and Carolyn Shaffer.

ABSTRACT

As the district with the latest harvest in California (through August and early September), Lake County pear fruit is vulnerable to late 2nd and 3rd generation codling moth damage during an interval when no cover sprays are applied. Previous experiments (1988-1994) had shown that the late season rendered mating disruption (MD) programs less effective than in earlier districts as populations increased year to year in treated orchards. In 1998 and 1999, building on initial experimentation in 1996 and 1997, pheromone dispensers were hung in late June or early July in seven 10-acre blocks in Mendocino (1998) and Lake (1999) Counties to disrupt mating of late season moths that may otherwise escape control. Trap catch and post-harvest infestation data from the 1996-1997 tests had shown that this method successfully reduced CM flight after hanging, and to a less significant extent, damage. Trap catch data had also shown that these effects carried over to the following spring, significantly reducing overwintering flight; data corroborating this will be taken from the 1999 hangings in spring 2000. Results in 1999 have so far corroborated those of earlier tests. Important as well, the number of organophosphate (OP) applications were reduced by two-thirds versus the standard comparison blocks, showing the use of one mid-season hanging compensated for lack of OP residue during the last half of harvest during August and early September. This advantage is even more important now that pre-harvest intervals for key OP's have been lengthened. The carryover effect will also enable growers to decrease cover spray amounts due to lower insect pressure and transition more rapidly to "softer" programs using more selective chemicals and/or MD. Another side benefit may be the reduction of current or future field resistance to OP's. Wider spread commercial implementation of this new tactic occurred in 1998 and 1999, as it is viewed as an effective transition or more economical MD strategy.

INTRODUCTION

Pheromone mating disruption (MD) has become more widely adopted on the North Coast in the past several years, largely due to areawide demonstration efforts funded by CalDPR and USDA. However, perceived high cost and lingering questions about efficacy have precluded universal adoption. On the North Coast, two applications of dispensers applied in late March and late June are still considered prudent, and in some years may be insufficient to prevent damage by worms hatching from late second and third flights during late July through early September. Likewise, insecticide residues may also "run out" before harvest, causing damage to late-picked fruit and rat-tails. This in turn increases the overwintering population and subsequent flights. The cancellation of encapsulated methyl parathion (i.e. Penncap M®) on pears in 1999 also threatens to cause increased codling moth pressure if there is resistance to azinphosmethyl (e.g. Guthion®).

Despite imperfect control, PCA's had observed that orchards treated with pheromones sustained reduced overwintering flight the following spring. It was therefore felt that pheromones could be used as a late-season "sanitation" tool to reduce the following season's CM pressure, thus giving MD and selective insecticides (e.g. insect growth regulators) more chance of success. This observation led to an experimental program in 1996-98 to test a transition program whereby one initial organophosphate (OP) application was followed by a single pheromone dispenser application to extend MD well past harvest. For Lake County, with its late harvest (through August and early September), and high probability of sustaining late second and third generation damage, this strategy offered a relatively economic means of reducing in-season CM pressure during the vulnerable period during harvest when chemical residues have decreased. Organophosphate use could also be immediately reduced, without sacrificing CM or oblique-banded leafroller (OBLR) control. In turn, overwintering flight the next season could also be greatly reduced, thereby lessening overall pressure and offering a greater chance of success if "soft" or alternative programs are implemented.

Initial testing of the late-season program, sponsored by the Pear Pest Management Research Fund, was very successful. Two years of trap catches (1996 late-season and 1997 overwintering flight) showed that one application of 400 Isomate® ties, applied in mid-July prior to harvest and the third CM flight, significantly reduced both current season mid-harvest and post-harvest infestation and overwintering flight the following season.

In 1996, trap catches in the five treated blocks were completely shut down in both 1 mg. and 10 mg. traps. In four out of five orchards, post-harvest larval damage was significantly reduced in treated blocks. In 1997, wing trap data showed overwintering flight was significantly reduced in 1996 late-season pheromone treated blocks. This was in contrast to 1996 overwintering flight numbers in the same blocks, which were at least equal to standard blocks before pheromones were applied in mid-July.

Based on 1996-1997 trial results, Lake County PCAs and growers gained access to a new tactic that was ready to be more widely demonstrated as the industry transitioned to an era of longer pre-harvest intervals and (eventually) full-season MD programs. In 1998 and 1999, several PCAs utilized the late-season hanging program commercially on several hundred acres in both Lake and Mendocino Counties. In 1999, demonstration blocks were also established in Lake County through the Pear Pest Management Alliance, in order to widen industry awareness and confirm previous results in a systematic manner.

PROCEDURE
Data Collection: To demonstrate the late-season hanging concept, one application of either Isomate-C® or Checkmate® pheromone dispensers was applied in late-June 1999 to five, 10-acre blocks in Kelseyville and Scotts Valley. All treated blocks received an initial Penncap M® application the third week of May; no other OP applications were made for the remainder of the season. The standard control blocks received the same initial OP treatment then follow-up applications at the discretion of PCAs. Two 1 mg. low, two 1 mg. high, and two 10 mg. high traps were hung in both treated and standard OP control blocks to monitor subsequent flights through September. CM degree-days were monitored using a UCIPM PestCast Campbell Scientific 10X weather station located in the project area. Data was downloaded daily from UCIPM PestCast web site. Eggs were sampled in late July and bins at harvest for worm damage. After harvest, 300 fruit left on the trees were sampled in both treated and control blocks to observe whether MD had prevented late second and third brood larval damage. Data was analyzed using a paired t-test and combined with two additional comparisons performed in Mendocino County in 1998 (post-hanging trap catch data only).

In 2000, two each 1 mg. low, 1 mg. high, and two 10 mg. high wing traps will again be hung in the Lake County pheromone-treated and control blocks in March and will be monitored until the end of the overwintering flight (through June). First generation codling moth damage will be sampled in June by examining 500 top and 500 bottom fruit from 20 trees in the center of each block. Harvest samples will be taken to determine if treatment effects last through the entire season. 1999 overwintering flight and damage data from Mendocino was not taken because the growers transitioned to full-season MD programs.

Data Extension: Participating PCAs, as well as the CalDPR project manager, received weekly emails of CM counts and damage. A field meeting was held in late July to inform PCAs and growers of progress on the project. Both English and Spanish meetings were held. Hispanic personnel were also trained to identify CM and OBLR in addition to being informed on the project. All who attended the Spanish session received hand lenses to use in the work.

RESULTS
1999 (Lake County) seasonal trap catches in one standard reference block are shown in Figure 1.

Codling moth and OBLR trap catches
CM flights for Lake and Mendocino, including OP applications, are shown in Figures 2 to 8. OBLR flights for Lake County only are shown in Figures 9-13 (for reference only).

In 1998 and 1999, 1 mg. low traps in the seven treated blocks in Lake and Mendocino Counties were completely shut down following dispenser application, resulting in a significant difference compared to control blocks. 1 mg. high catches were nearly shut down and highly significantly different versus catches in untreated blocks. 10x high trap catches, shown for Lake County only, were five times less than in controls, but were not statistically different than untreated. This may have been due to lack of enough replications; for example, when Mendocino blocks were included in the analysis of 1x low catches, differences were more apparent than when Lake 1x trap catches were analyzed alone. Also, 10x traps are known to be less informative in non-MD blocks (Tables 1-5).

Egg damage and post-harvest samples

July egg numbers (Lake County only) were significantly lower (p=0.10). Data taken by Dr. Broc Zoller in 12 commercial blocks showed even greater differences between late-season treated and non-treated blocks (Tables 6 and 7).

Damage at harvest was zero in both treatments in the two Mendocino blocks in 1998. In the Lake County blocks in 1999, damage was reduced (though insignificantly) versus standard blocks (Table 8). Post-harvest samples likewise failed to show significant differences, unlike in 1996. This was likely due to the (fortunate) lateness of the third flights (data not shown).

Organophosphate use reduction

The late-season hanging program significantly reduced OP use by 61%, from an average of 2.6 treatments in the standard blocks to one in the treated blocks (p = .003, paired t-test; data available for six out of seven blocks).

CONCLUSIONS

Two years of trap catches (1998 and 1999 post-hanging) corroborated previous findings that a single application of dispensers, applied in late June after an initial organophosphate treatment, effectively reduced CM flight and egg laying for the remainder of the season. Final data on the 2000 overwintering flights in Lake County will confirm the season-to-season effect on trap catches and first generation damage.

Damage at harvest was also reduced, though is less easily discernible due to wide variability in initial orchard pressure, in-season pest control programs, and picker discretion. Effect on post-harvest infestation is also subject to greater orchard-to-orchard and season-to-season variability, though differences were clearly shown in 1996.

The late-season hanging program significantly reduced the number of organophosphate applications from nearly three to one in the initial year of implementation.

Despite the variables mentioned above, experience with the technique gained over the past four years has led to widespread adoption by several PCAs and many growers in both Lake and Mendocino Counties as a means of immediately reducing organophosphate use and transitioning cost-effectively to full season MD programs.

ACKNOWLEDGEMENTS

The Project Leader and Collaborators wish to thank growers Ken Barr, Greg Hanson, John Hildebrand, Brent Holdenried, Nick Ivicevich, Morgan and Chris Ruddick, and Steve Thomas.

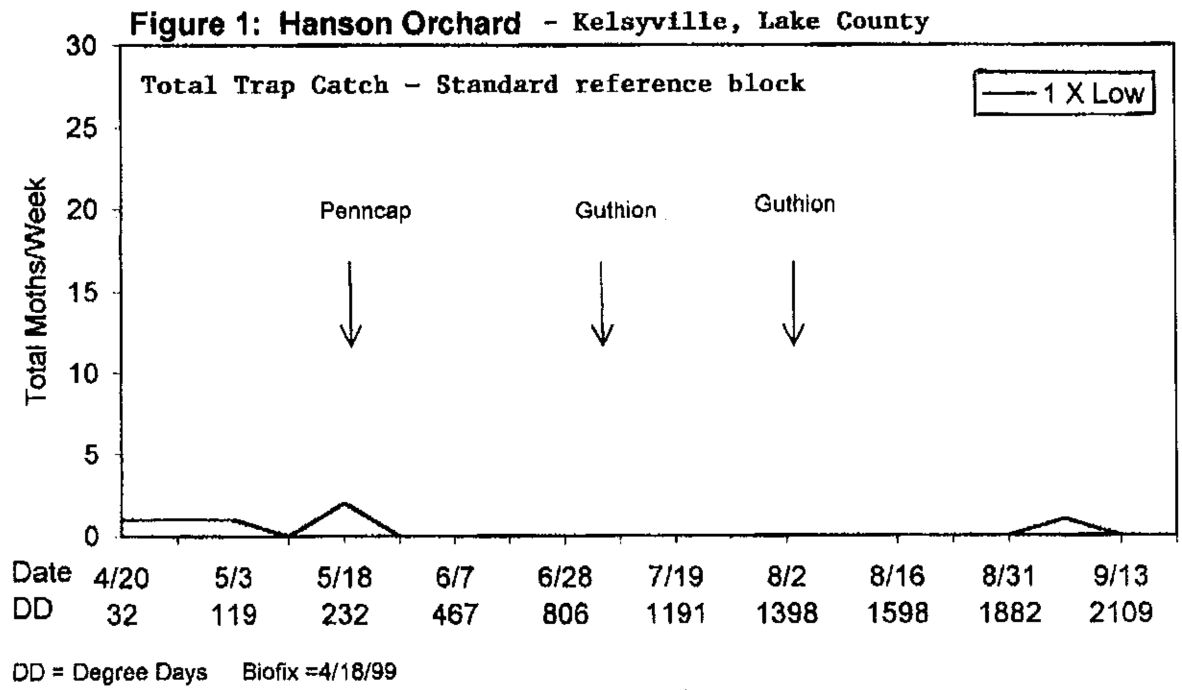
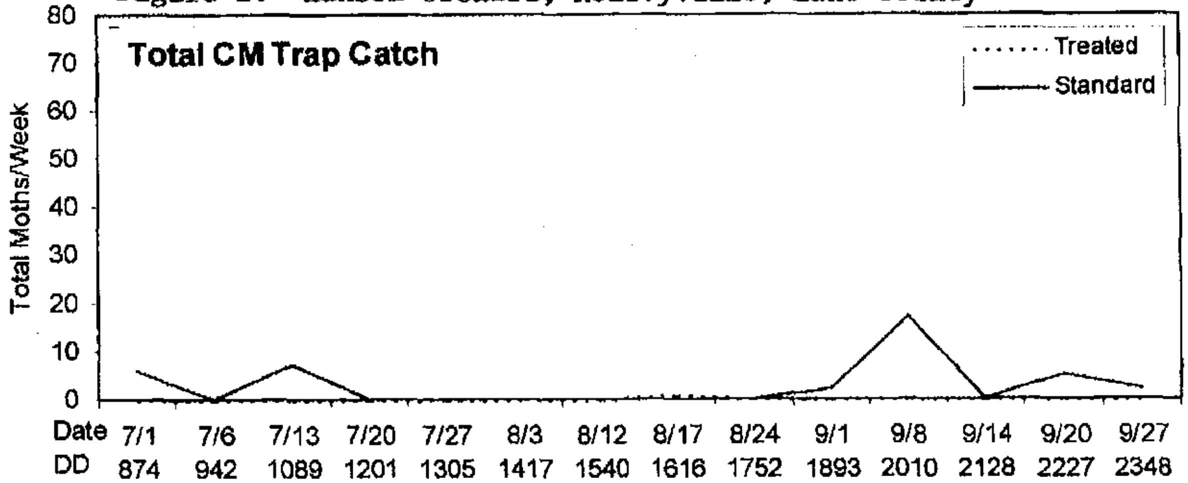
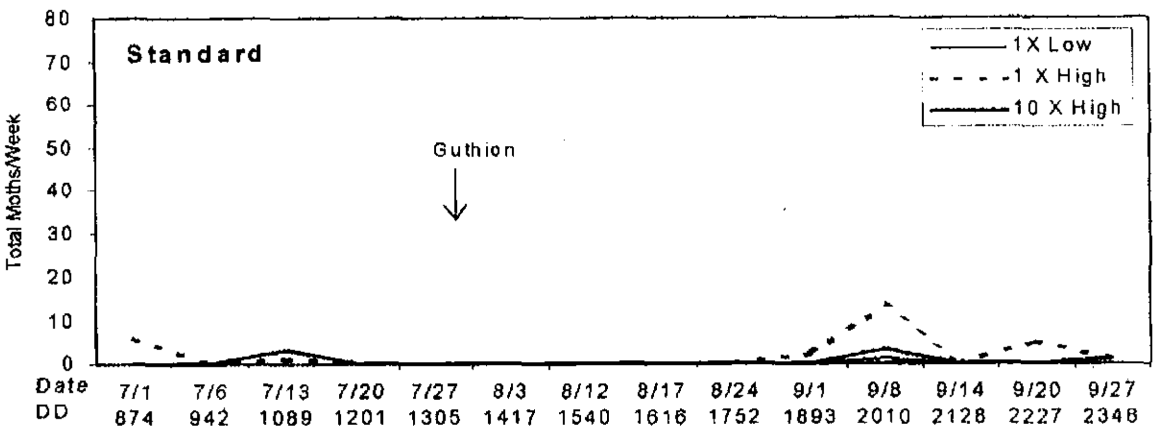


Figure 1: Hanson Orchard - Kelsyville, Lake County
Total Trap Catch - Standard reference block
1 X Low
Penncap
Guthion
Guthion
Total Moths/Week
30
25
20
15
10
5
0
Date 4/20 5/3 5/18 6/7 6/28 7/19 8/2 8/16 8/31 9/13
DD 32 119 232 467 806 1191 1398 1598 1882 2109
DD = Degree Days Biofix =4/18/99

CODLING MOTH TRAP CATCHES
JULY - SEPTEMBER 1999

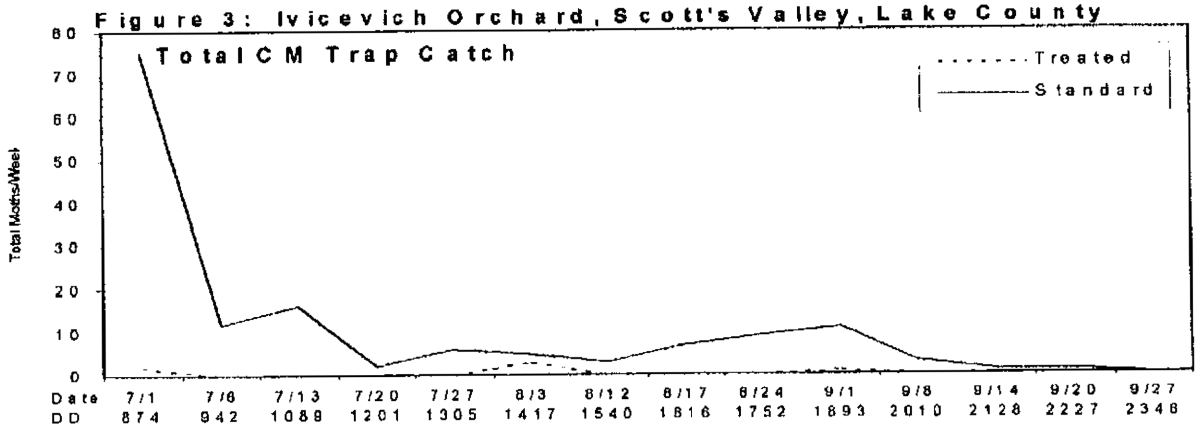
Figure 2: Hanson Orchard, Kelseyville, Lake County

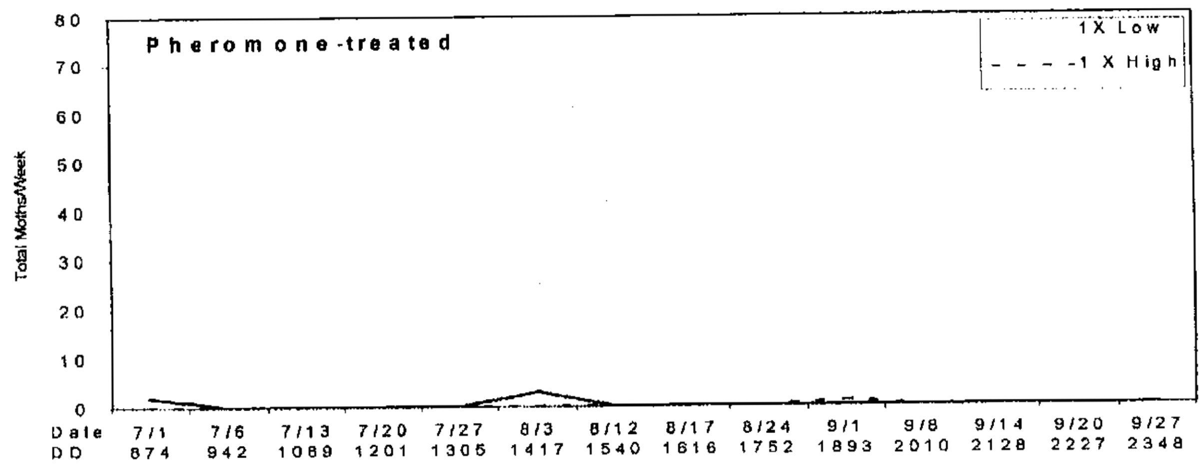




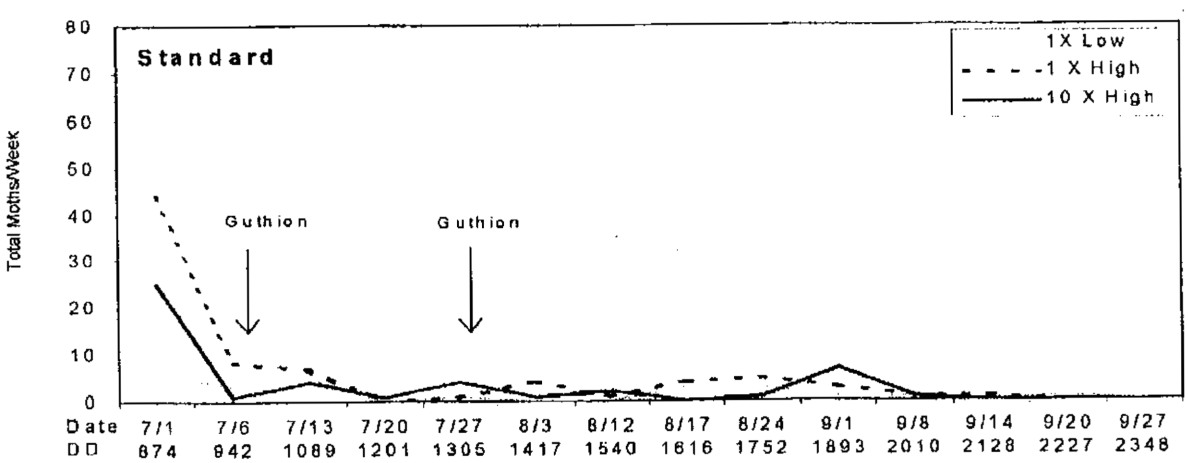
Penncap applied 5/17/99. Guthion applied 6/28 and 7/28/99.
DD = Degree Days Biofix = 4/18/99

Figure 3: Ivicevich Orchard, Scott's Valley, Lake County



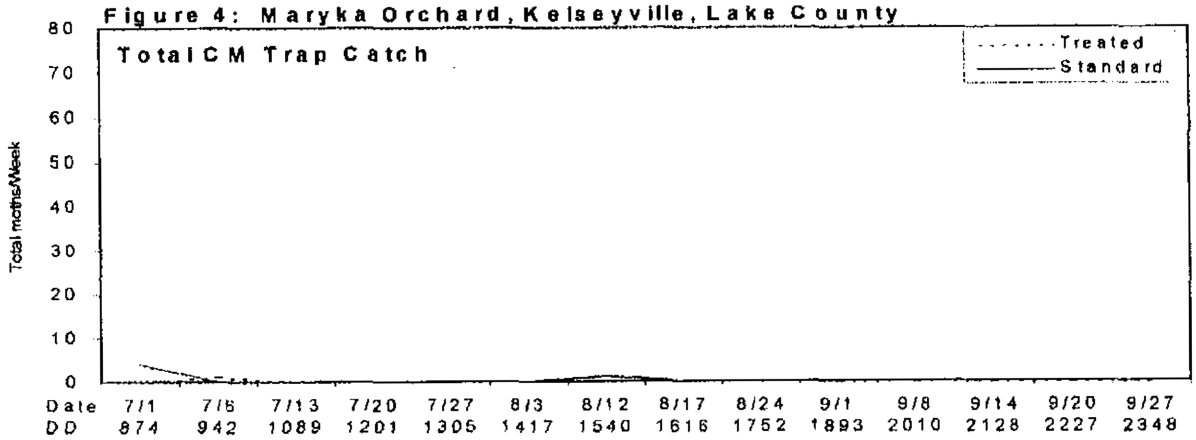


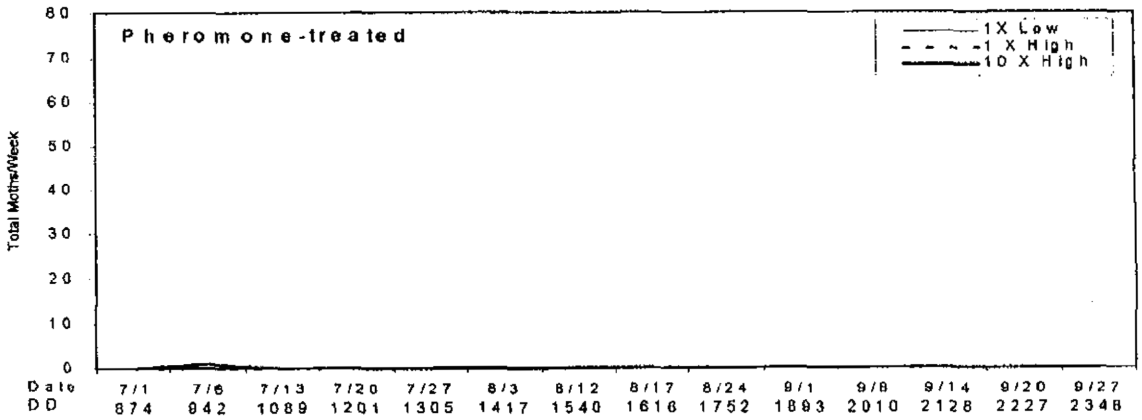
Penncap applied 5/18/99



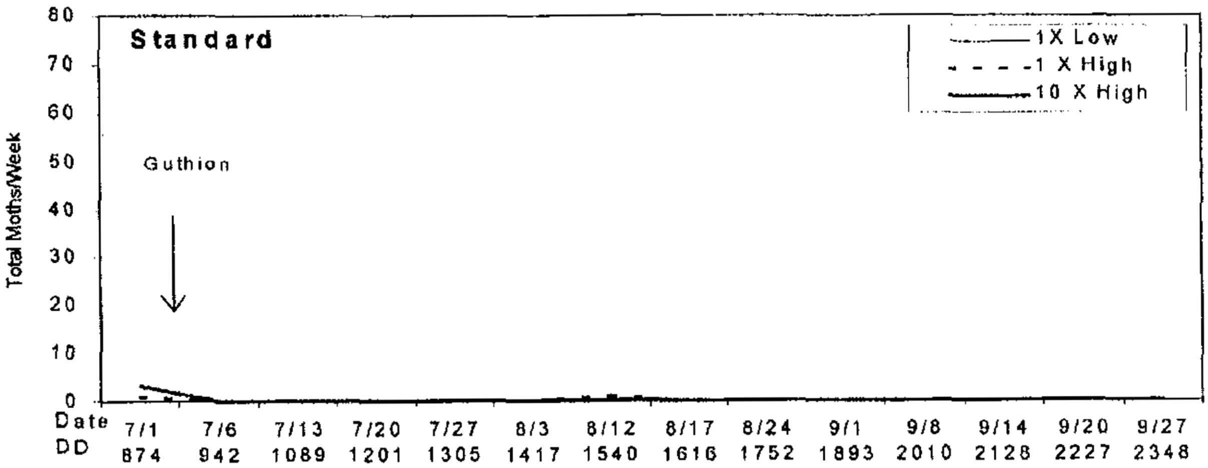
Penncap applied 5/18/99 DD = Degree Days Biofix = 4/18/99

Figure 4: Maryka Orchard, Kelseyville, Lake County



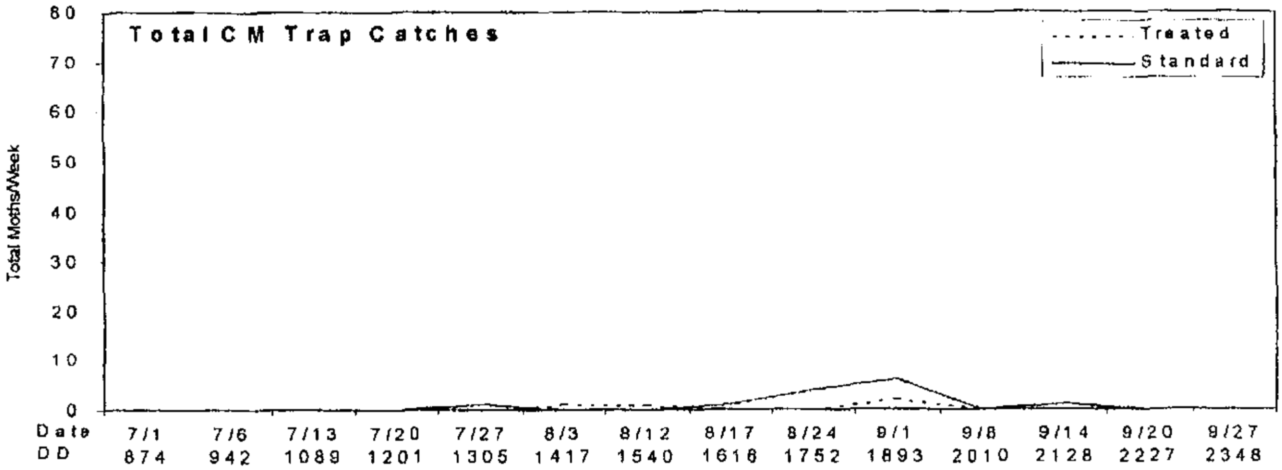


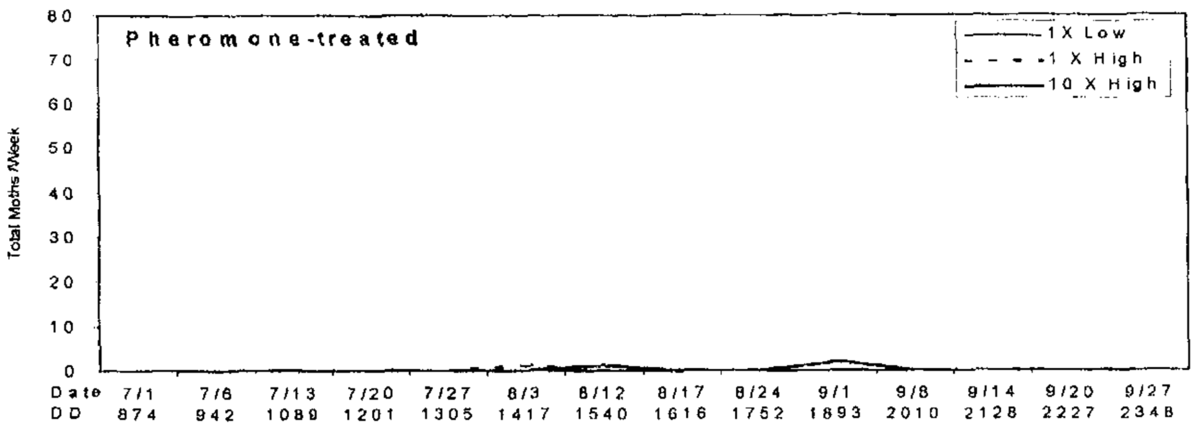
Penncap applied 5/14/99



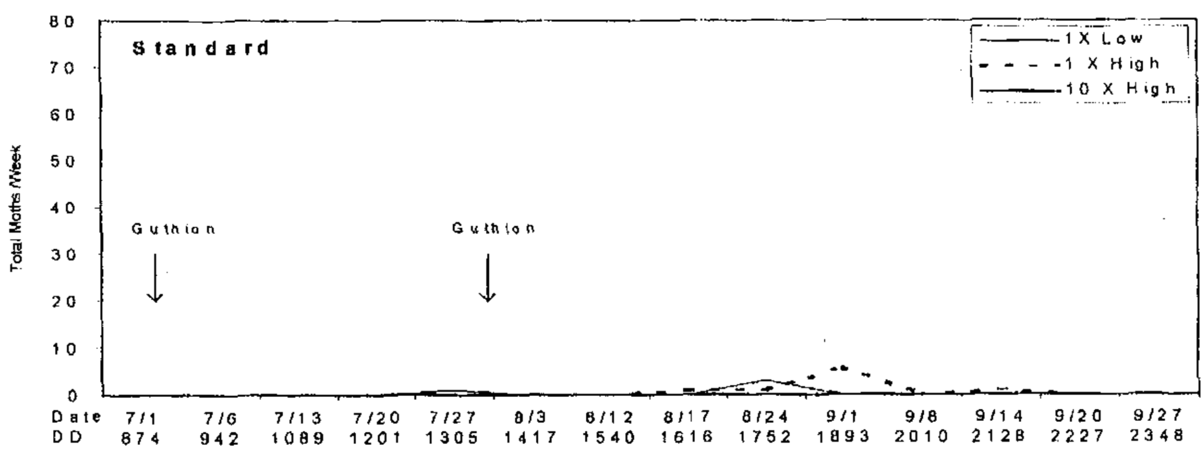
Penncap applied 5/14/99 DD = Degree Days Biofix = 4/18/99

Figure 5: Rancheria Orchard, Lakeport, Lake County



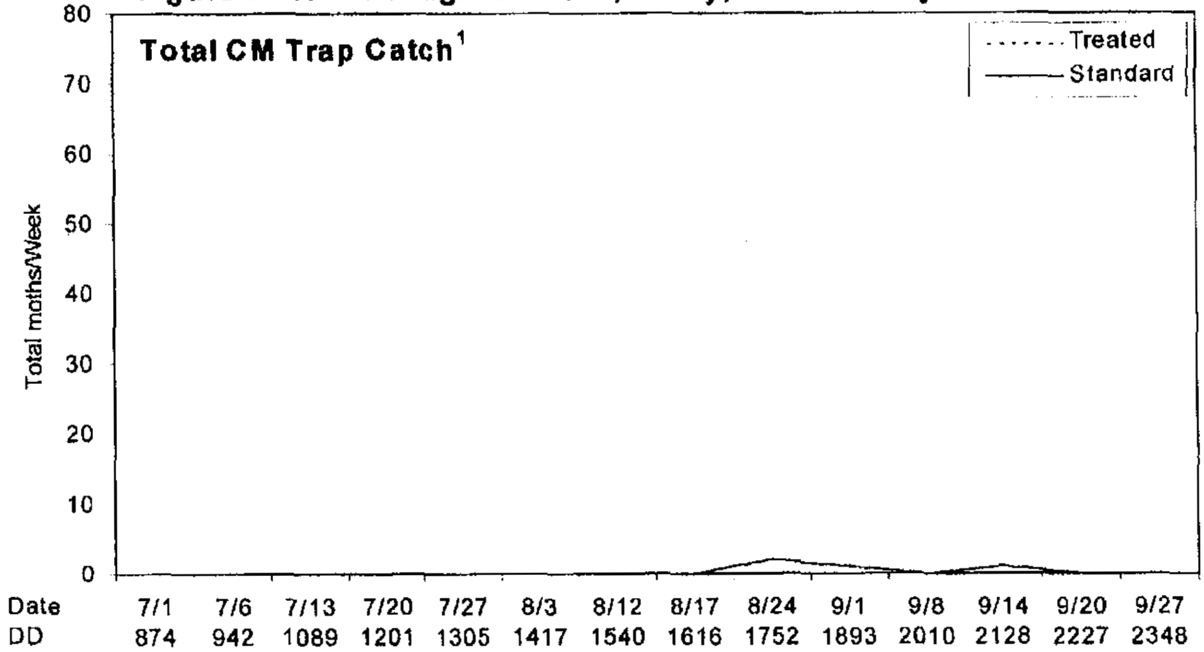


Penncap applied 5/20/99

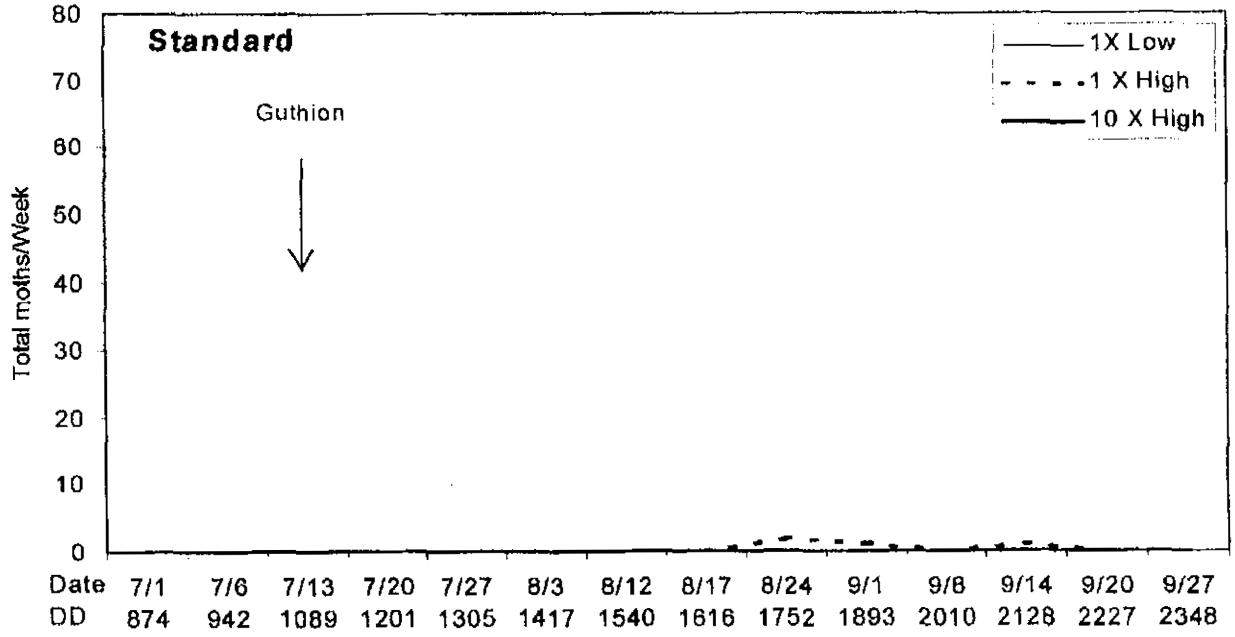


DD = Degree Days Biofix = 4/18/99 Penncap applied 5/20/99

Figure 6: Rickabaugh Orchard, Finley, Lake County

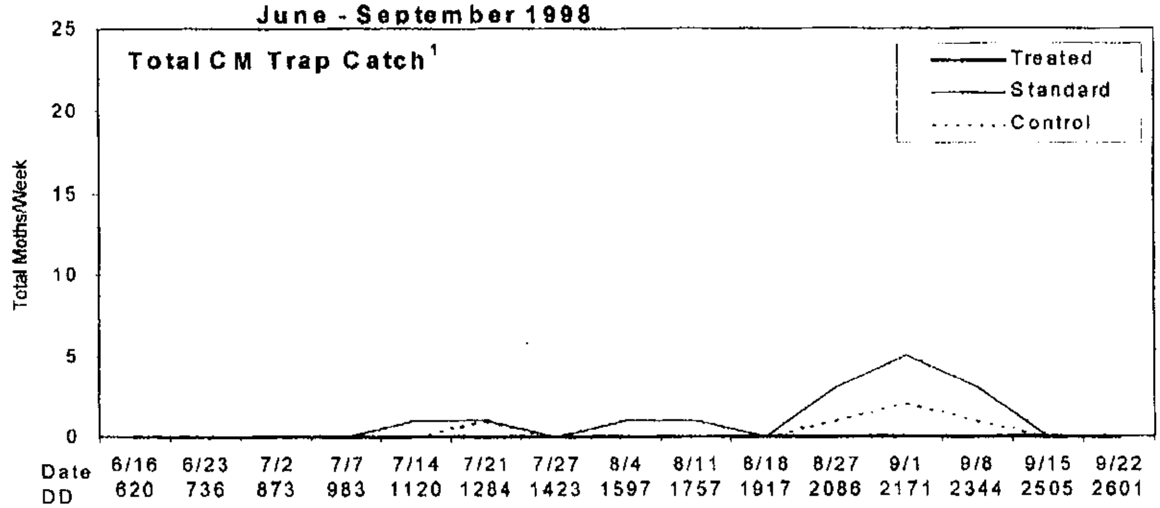


Penncap applied to treated plot 5/14&19/99 (one split spray). [1] No CM caught in pheromone-treated plot.

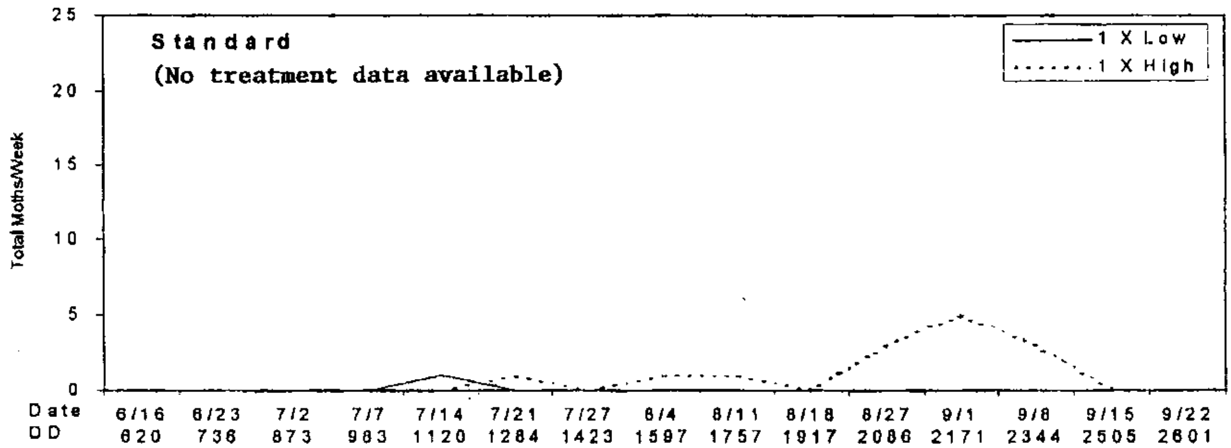


Penncap applied 5/17-21/99 DD = Degree Days Biofix = 4/18/99

Figure 7: Ruddick Ranch, Talmage, Mendocino County
June - September 1998



[1] No CM caught in pheromone-treated plot



DD = Degree Days

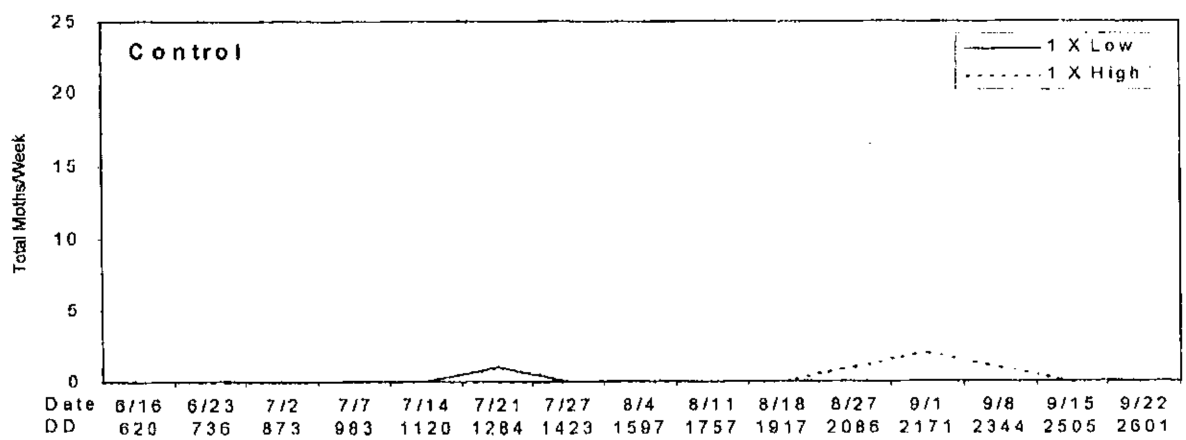
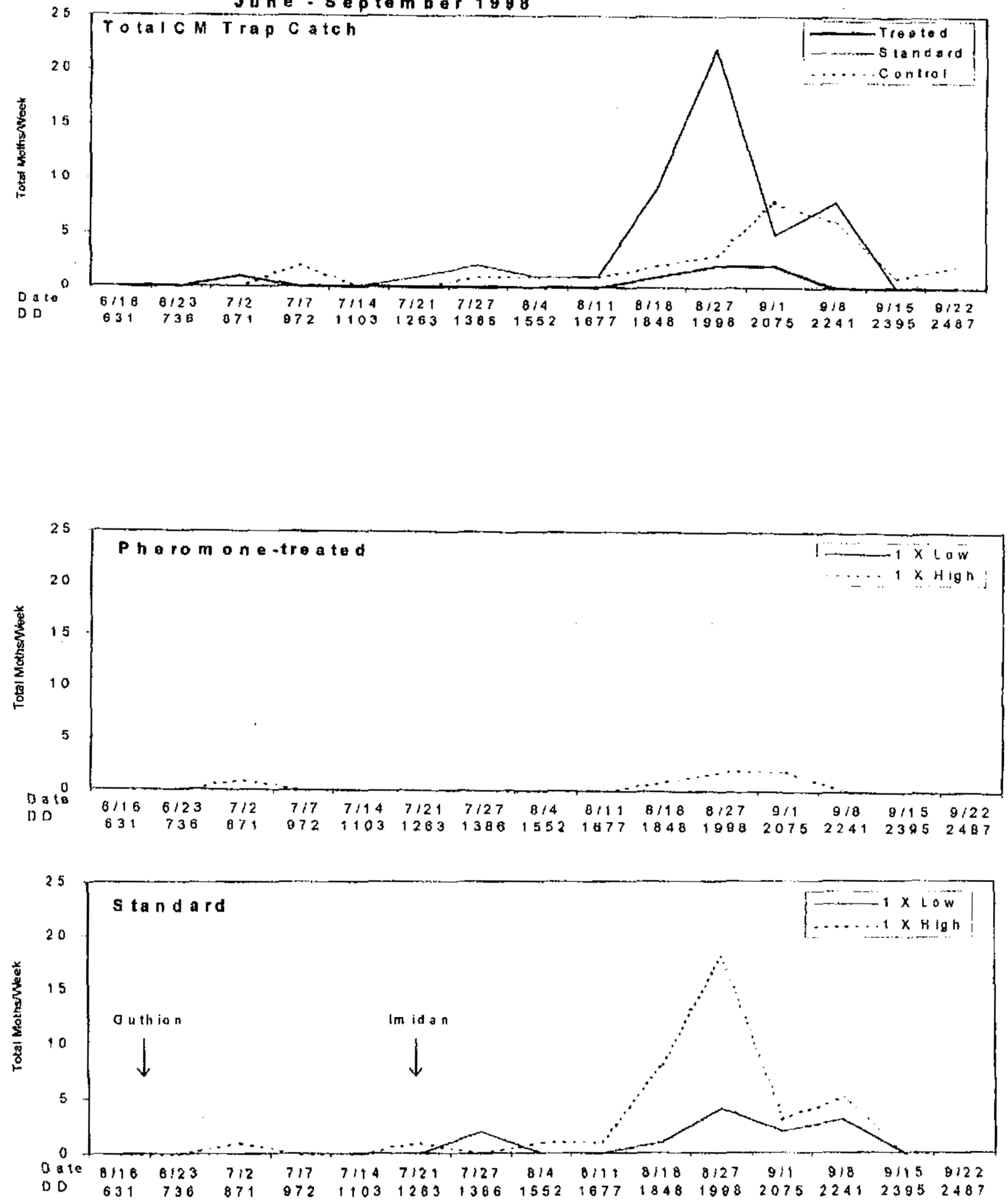
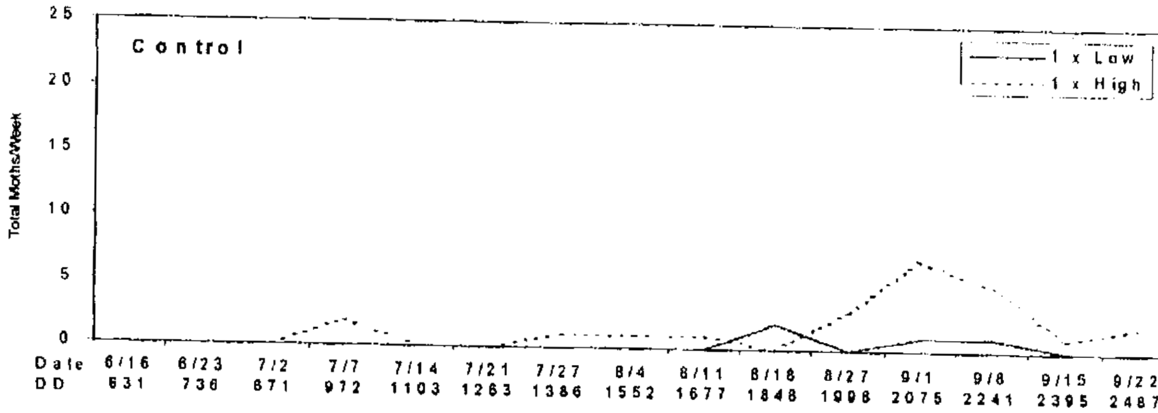


Figure 8: Thomas Bros. Orchard, Hopland, Mendocino County
June - September 1998

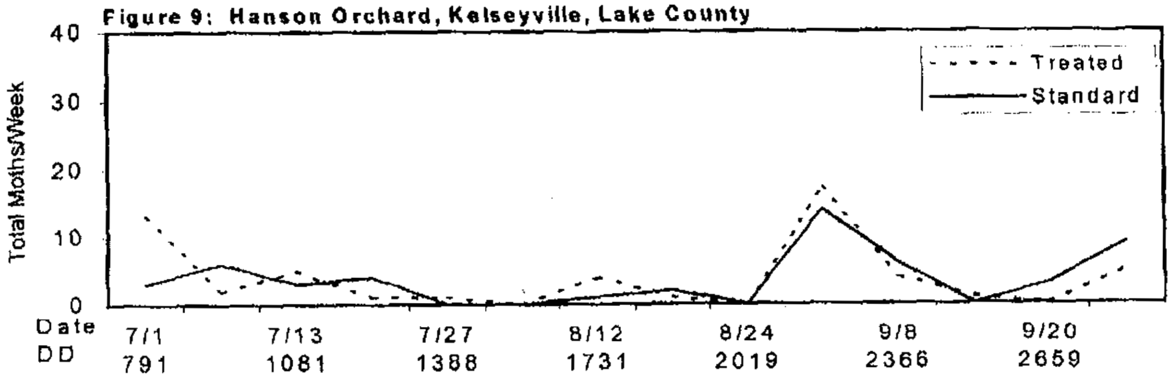


Penncap applied 5/21/98



OBLR TRAP CATCHES
JULY - SEPTEMBER 1999

Figure 9: Hanson Orchard, Kelseyville, Lake County



DD = Degree Days Biofix = 5/25/99

Figure 10: Ivicevich Orchard, Scott's Valley, Lake County

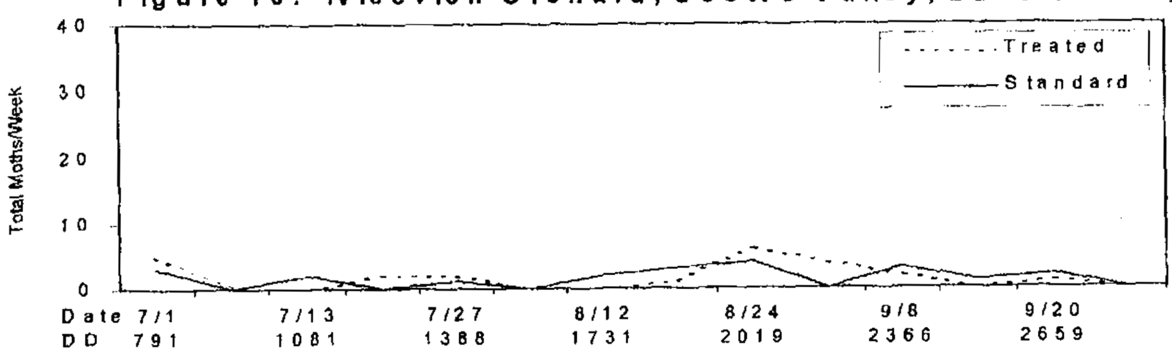


Figure 11: Maryka Orchard, Kelseyville, Lake County

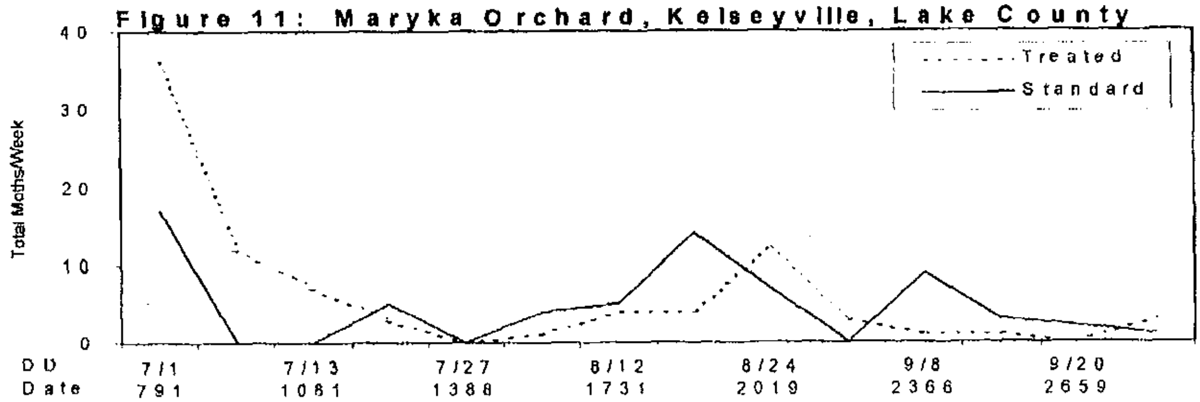
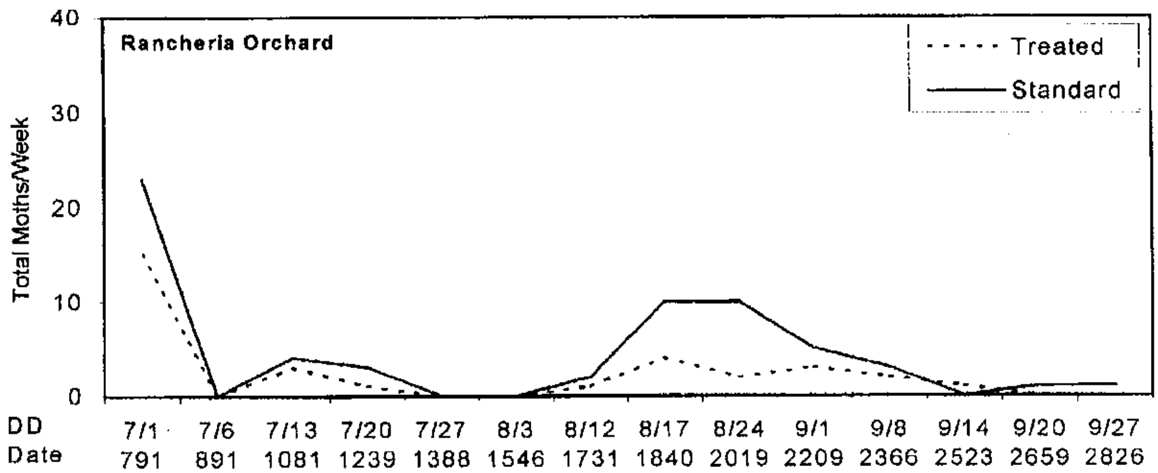


Figure 12: Rancheria Orchard, Lakeport, Lake County



DD = Degree Days Biofix = 5/25/99

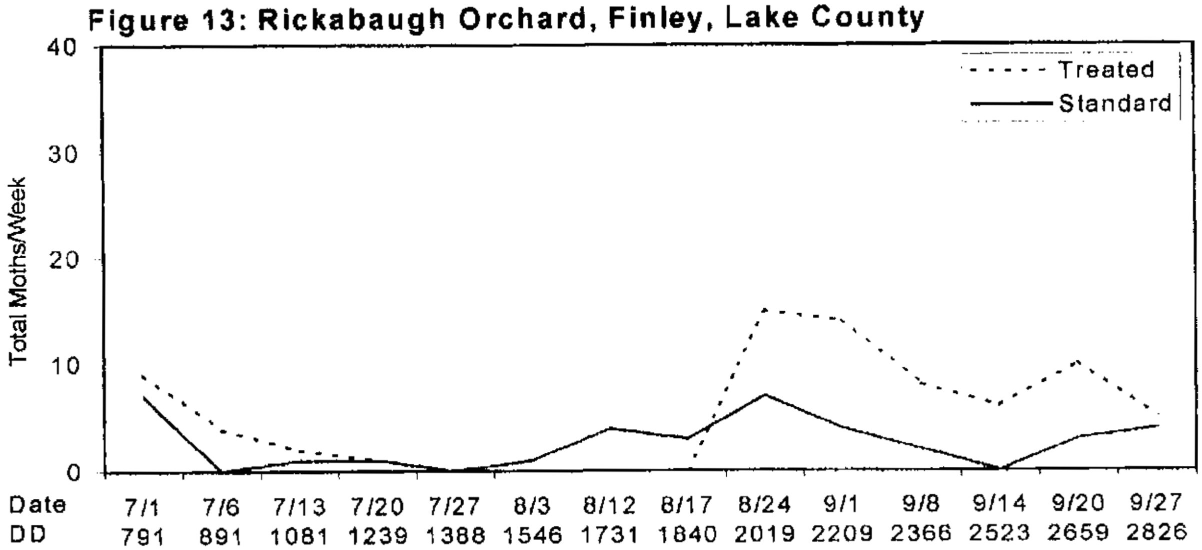


Figure 13: Rickabaugh Orchard, Finley, Lake County
40
30
20
10
0
Total Moths/Week
Treated
Standard
Date
DD
7/1 7/6 7/13 7/20 7/27 8/3 8/12 8/17 8/24 9/1 9/8 9/14 9/20 9/27
791 891 1081 1239 1388 1546 1731 1840 2019 2209 2366 2523 2659 2826

LATE-SEASON PHEROMONE HANGING
POST-HANGING CODLING MOTH TRAP CATCHES
Lake and Mendocino Counties, 1998 and 1999 Combined
Average Catch Per Two Traps

Table 1: **Lake County:** 874 - 2348 °D **Mendocino County:** 631 - 2487 °D

BLOCK	1 MG. LOW		1 MG. HIGH	
1999	**Pheromone**	**Standard**	**Pheromone**	**Standard**
LAKE COUNTY				
Ivicevich	0	12	0.5	39.5
Rancheria	0	2	0.5	4.5
Rickabaugh	0	0	0	2
Maryka	0	0	0	1
Hanson	0	2	0	14
1998				
MENDOCINO COUNTY				
Thomas Bros.	0	6	3	19
Ruddick	0	0.5	0	7
	*	*	**	**

Paired t-test: * significant at $p = 0.05$, ** significant at $p = 0.01$.

Data analyzed using square root transformation $(x + .5)^{.5}$.

1999 LAKE COUNTY LATE-SEASON PHEROMONE HANGING DEMONSTRATION PLOTS

Table 2:

Total Codling Moth/OBLR Trap Catches[1] - Lake County
July - September 1999

TRAP TYPE	BLOCK		
	TREATED[3] (5 Plots)	STANDARD (5 Plots)	PAIRED t-TEST RESULTS
CM 1X LOW	0	32	NS (0.14)
CM 1X HIGH	2	122	NS (0.06)[2]
CM 10X HIGH	10	57	NS (0.31)
OBLR W/H	270	238	NS (0.65)

[1] One trap of each type per 5 acres
[2] Significant at $p \leq 0.10$. Data analyzed using square root transformation $(x+.5)^{.5}$.
[3] Isomate C dispensers, 400/acre, hung June 1-10, 1999 (422 - 498 CM °D)
CM biofix April 18,1999; **OBLR** biofix May 25, 1999

Table 3:

Codling Moth and OBLR Trap Catches
Total Catches July - September 1999

TREATMENT/BLOCK	TRAP TYPE				
	1 X LOW	1 X HIGH	10 X HIGH	Block Total	OBLR
Pheromone-treated					
Ivicevich	0	1	5	**6**	23
Rancheria	0	1	3	**4**	32
Rickabaugh	0	0	0	**0**	74
Maryka	0	0	1	**1**	87
Hanson	0	0	1	**1**	54
Total pheromone-treated	**0**	**2**	**10**	**12**	**270**
Standard					
Ivicevich	24	79	47	**150**	21
Rancheria	4	9	0	**13**	62
Rickabaugh	0	4	0	**4**	37
Maryka	0	2	3	**5**	67
Hanson	4	28	7	**39**	51
Total standard	**36**	**122**	**57**	**215**	**238**

1998 LATE-SEASON PHEROMONE HANGING DEMONSTRATION PLOTS

Total Codling Moth Trap Catches - Mendocino County

Table 4: **June - September 1998**

TRAP TYPE	BLOCK		
	CONTROL[1] (2 Plots)	STANDARD[2] (2 Plots)	PHEROMONE[2] (2 Plots)
1X LOW	5	13	0
1X HIGH	27	52	6

[1] Control: one trap each type.

[2] Standard and Pheromone: average of two traps for each type.

Average Codling Moth Trap Catches

Table: 5: **June - September 1998**

TREATMENT/BLOCK	TRAP TYPE	
	1 X LOW	1 X HIGH
Pheromone-treated[1]		
Thomas Bros.	0	3
Ruddick Ranch	0	0
Standard[1]		
Thomas Bros.	6	19
Ruddick Ranch	0.5	7
Control[2]		
Thomas Bros.	4	23
Ruddick Ranch	1	4

[1] Average of two traps for each type. [2] One trap each type.

1999 LAKE COUNTY LATE-SEASON PHEROMONE HANGING DEMONSTRATION PLOTS

CM Egg Counts - %/300

Table 6: **July 20-21, 1999;** 1201 - 1215 °D

TREATMENT/BLOCK	EGGS
Pheromone-treated	
Ivicevich	0.0
Rancheria	0.0
Rickabaugh	0.0
Maryka	0.0
Hanson	0.0
Average pheromone-treated	**0.0**
Standard	
Ivicevich	0.7
Rancheria[1]	0.0
Rickabaugh	0.0
Maryka	0.7
Hanson	0.3
Average standard[2]	**0.3**
t-test results	**0.09***

[1] 150 fruit from bottom only

[2] All eggs were black caps found in tops

* Significant at $P \leq 0.10$.

COMMERCIAL LATE-SEASON
PHEROMONE HANGING COMPARISON

CM Egg Counts - %/Block (500-7000/block)

Broc Zoller: Pear Doctor Inc.

Table 7: **Lake County, July - August 1999**

TREATMENT/BLOCK	EGGS
Pheromone-treated	
Seely	0.0
Weiss	0.0
J. Thomas	0.05
S. Thomas	0.0
ACO	0.0
EAT	0.0
Dorn	0.0
Field	0.0
Holdenried	0.0
Henderson	0.0
Rohner	0.0
Stokes	0.0
Average pheromone-treated	**0.004**
Standard	
Seely	0.0
Weiss	0.2
J. Thomas	0.05
S. Thomas	0.07
ACO	0.03
EAT	0.04
Dorn	0.0
Field	0.05
Holdenried	0.0
Henderson	0.0
Rohner	0.0
Stokes	0.05
Average standard	**0.04**
t-test results	**0.04***

*Significant at $P \leq 0.05$.

Data analyzed using square root transformation $(x + .5)^{.5}$.

1999 LAKE COUNTY LATE-SEASON
PHEROMONE HANGING DEMONSTRATION PLOTS
Codling Moth and OBLR Damage

Table 8: **Bin Fruit Samples - %/1000 August 16 - September 5, 1999**

TREATMENT/BLOCK	Codling Moth			OBLR		
	1 st pick	2nd pick	Total	1 st pick	2nd pick	Total
Pheromone-treated						
Ivicevich	0.0	-	0.0	0	-	0.0
Rancheria	0.0	-	0.0	0.7	-	0.7
Rickabaugh	0.0	-	0.0	0.1	-	0.1
Maryka	-	-	-	-	-	-
Hanson	0.1	-	0.1	0.0	-	0.0
Average pheromone-treated	**0.03**	-	**0.03**	**0.2**	-	**0.2**
Standard						
Ivicevich	0.9	0.0[1]	0.9	0.6	0.0[1]	0.6
Rancheria	0.0	-	0.0	0.8	-	0.8
Rickabaugh	0.0	-	0.0	0.3	-	0.3
Maryka	-	-	-	0.4	-	0.4
Hanson	0.0	-	0.0	1.3	-	1.3
Average standard	**0.23**	**0.0**	**0.23**	**0.7**	**0.0**	**0.7**
t-test results			**NS (0.48)**			**NS (0.12)**

[1] %/600 fruit

NS indicates not significant at $P \leq 0.10$. Data analyzed using square root transformation $(x + .5)^{.5}$.

OPTIMAL USE PATTERN OF PSEUDOMONAS FLORESCENS A506 (BLIGHTBAN A506®) TO CONTROL FIRE BLIGHT AND RUSSET IN PEARS

(Report submitted to the Pear Pest Management Alliance)

Project Leaders: Rachel Elkins and Steve Lindow

Research Assistants: Jim Benson, Dustin Blakey, Sarah Davis, Eileen Haxo, Donna King, and Marianne Seidler

ABSTRACT

Fire blight disease caused by the bacteria Erwinia amylovora has been shown over the past decade or so to be partially controlled by the biological control agent Pseudomonas florescense A506, currently sold as Blight Ban A506® by Plant Health Technologies. Recent research has shown that A506 is capable of colonizing blossom tissue at lower than current label rates as long as conditions for colonization exist.

A demonstration project was conducted in a Bartlett pear orchard in Wheatland, Yuba County to show that A506 could be applied at half the labeled rate and still allow antibiotic use to be reduced by 50-60%. Treatments applied by commercial spray rig consisted of full rate, half rate, or no A506, combined with either full or reduced numbers of streptomycin applications.

Results corroborated those of previous trials. The half rate of A506 colonized blossoms as well as the full rate when each was applied three times from March 22 through April 14. Fire blight efficacy was not rated as disease appeared six weeks after the final A506 and antibiotic applications, long after the antagonist had ceased activity. 1999 was also a very dry year, eliminating differences in russet suppression.

Using the half rate of A506 and 66% of normal antibiotic sprays also reduced total program material cost from $63 to $36 per acre, only $7 per acre more than the full stand-alone antibiotic program.

Plans in 2000 are to apply A506 pre-bloom with a silicon surfactant in order to penetrate unopened tissue and establish A506 prior to bloom. Follow up application(s) will be made to early summer rat-tail blooms which appear to cause the greatest amount of disease in this orchard.

INTRODUCTION

Fire blight disease caused by Erwinia amylovora is the most severe disease of pear in California. Its incidence limits where pears can be grown, as well as requires great expense and vigilance to control. Control of the disease involves cutting out infected tissue and applying preventative antibiotic or copper treatments when infection is likely. Resistance to one of the two antibiotics, streptomycin, has reduced control options. Copper, while effective, causes fruit russeting, which reduces fresh market value.

Research by UC plant pathologist Dr. Steve Lindow has led to the commercial availability of a biological control agent, Pseudomonas florescens A506, marketed as BlightBan A506®, by Plant Health Technologies. A506 works by colonizing flower tissue, thereby preventing colonization of flowers by the fire blight pathogen and other russet-inducing bacteria. Trials over the past decade have shown that fire blight and russet are reduced about 50% by A506 alone, and that it provides additive control when used in conjuction with streptomycin.

Commercial adoption of A506 has been hindered by several factors: 1) it is suppressed by the antibiotic terramycin and by copper and thus needs to be applied separately (it is totally resistant, however to streptomycin); 2) there is evidence that it is suppressed by certain scab fungicides, particularly mancozeb (Dithane®), and 3) it adds to an already costly fireblight control program.

Data from the past several years has shown that cost savings could be achieved without sacrificing efficacy by applying lower rates of A506. It had also been shown that fewer applications of antibiotics were necessary in an A506 program, thus reducing both chances of resistance build up and program cost.

In 1999, a demonstration trial was established in a Bartlett pear orchard in Wheatland, Yuba County, to show growers that:

1) Adequate colonization could be achieved by using a half-rate of A506
2) The number of antibiotic applications could also be reduced;
3) A506 would reduce fruit russet if russet conditions prevailed.

The demonstration was carried out in an orchard with chronic fire blight.

PROCEDURE

An 18-acre block of Bartlett pears was divided into six sections of eight rows each. Three treatments were applied to two sections each: 1) A506, three times at full rate (5.3oz./acre), 2) A506, three times at half rate (2.7oz./acre), and 3) no A506. Within each section, four rows received a full antibiotic program and four rows a reduced number of antibiotic sprays. Each complete treatment was thus replicated twice.

A506 and antibiotics were applied at 100 gallons per-acre by the grower using a commercial air blast sprayer. A506 was applied three times beginning at 20% bloom (March 22-23) through April 14. Agrimycin (agricultural streptomycin) was applied through April 17. Each treatment consisted of two back-to-back every-other-row applications. The full treatment rows received six applications while the less-treated rows received four applications. Immediately after the first A506 application, and weekly thereafter, newly-opened blossoms were rubbed onto petri dishes containing agar allowing only growth of strain A506. Each dish was divided into nine sections, and 27 flowers were sampled per plot at each date. Dishes were brought to the laboratory and held for three days to allow the A506 to grow. The colonized sections were then recorded as no growth, some growth, or vigorous growth. A total of six samples were collected.

For graphing and analysis, the sample data was converted into ratings using weighted averages (1.0 = no growth to 3.0 = maximum growth). Analysis of variance was performed on ranked transformed data using the Kruskal-Wallis ANOVA for Ranks. This revealed which effects were significant (i.e. level of A506 and level of antibiotic).

Fire blight strike evaluation: During the period of treatment, the grower regularly observed incidence of fire blight in the plot area. Fire blight was observed in rat-tail bloom in early June, six weeks after the last A506 and antibiotic treatments were applied. The number of strikes in each plot was recorded once on June 7. Shoot strikes were observed in late June, but were not counted due to the long time lag between fire blight treatments and observed outbreak.

Russet evaluation: About 100 fruit per plot were collected prior to harvest on August 14 and taken back to UC Berkeley for evaluation of the severity of fruit russet.

Program cost: Material cost per acre for each of the six programs was calculated.

Extension of information: Results of the demonstration will be reported at the annual winter pear research meetings in February 2000 and in trade journals.

RESULTS

The pattern of A506 colonization through the season is shown in Figures 1 and 2. The six lines of Figure 1 show each A506 x antibiotic treatment separately, while Figure 2 combines each A506 treatment regardless of antibiotic use. Both figures show a pattern of similar colonization by both the half and full rate versus very little in the control. The apparently better colonization by the half rate early in the season may be attributed to sampling technique, field variability, or chance. Table 1 shows the statistical relationship of the three A506 treatments.

Table 1: Rating of A506 Population – average of 36 samples

Treatment	Rating
A506 – full rate	1.98 a b
A506 – half rate	2.16 a
no A506	1.21 b

Significant at p = 0.05; means separated by Kruskal-Wallis ANOVA for Ranks.
Rating of 2.0 or more is desirable. No significant differences between antibiotic rates (p = 0.39)

Figure 1: Colonization of pear flower blossoms by A506. Rating of 2.0 or higher is optimal. Effect of antibiotic on colonization was insignificant.

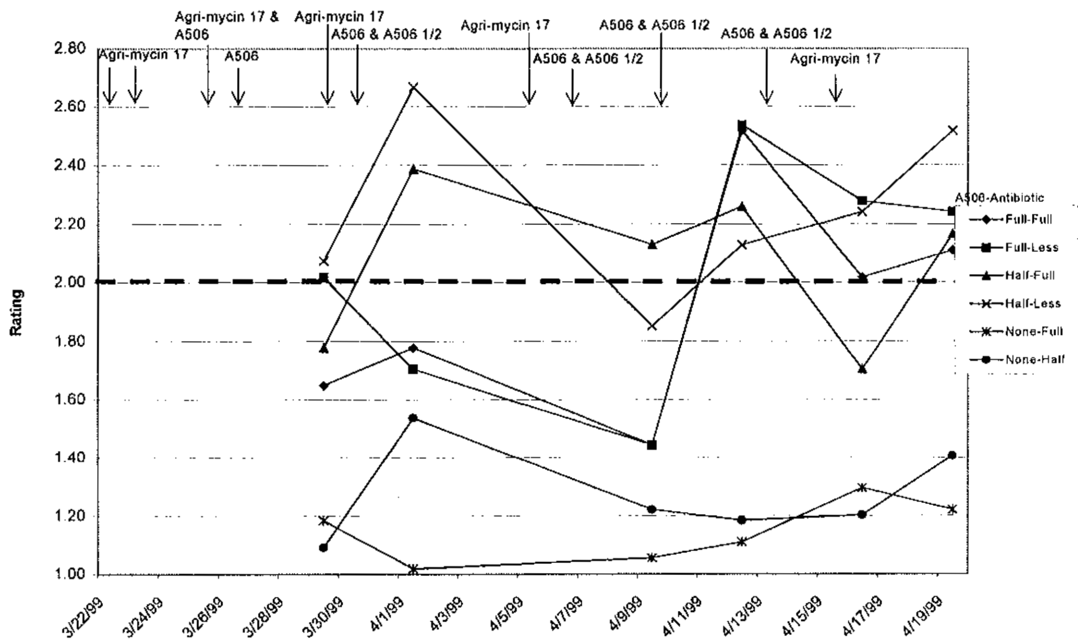
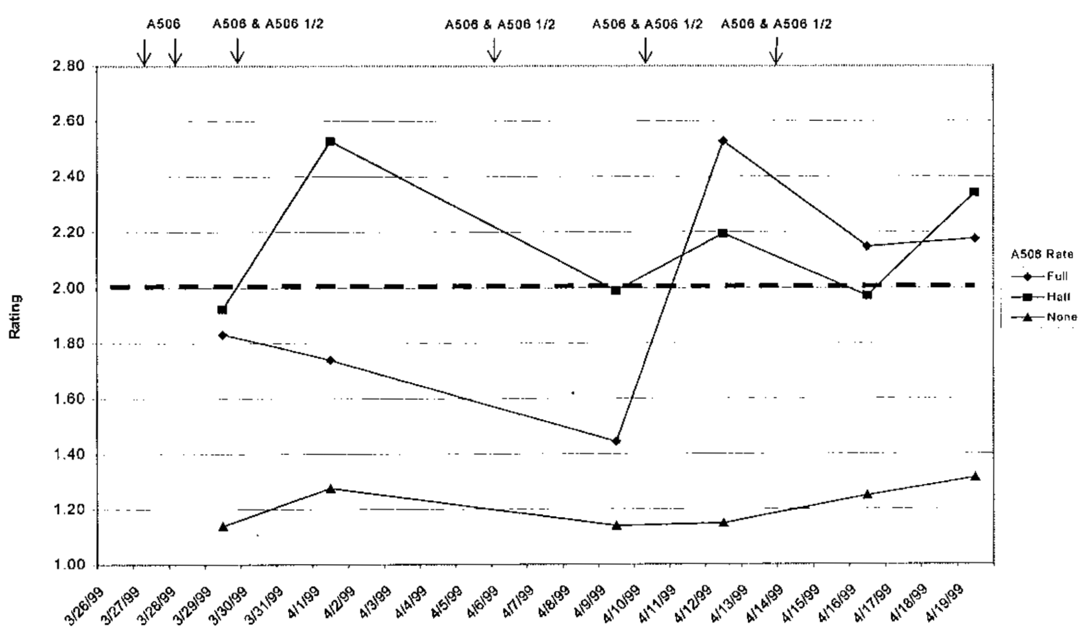


Figure 2: Colonization of pear flower blossoms by P. florescens A506, combining antibiotic treatments. Rating of 2.0 or higher is optimal. Colonization of blossoms by full and half rate was statistically equal (p = 0.05).



Fire blight control: A506 and antibiotic treatments ceased after mid-April, and the final sample was taken April 21. Fire blight strikes in rat-tail blooms were observed the first week of June, well after treatments and sampling ceased. The number of fire blight strikes in each plot was sampled on June 7, but no clear pattern emerged, due to 1) the long interval between treatments and infection, and 2) great differences in the number of holdovers from one end of the orchard to the other. Samples of blighted shoots collected in early June revealed previously undocumented resistance to streptomycin, the only antibiotic historically used in the orchard for fire blight control.

Russet control: 1999 was a very dry year so russet severity was very low and differences in russeting among treatments were non-significant (Table 2).

Table 2: Severity of fruit russet on pear at harvest from trees treated at bloom with Pseudomonas fluorescens strain A506 and/or antibiotics

A506 Applied	A506 Rate (% of label)	Antibiotic (% of normal)	Fruit Russet (% of surface)
Yes	100	100	0.88 a
Yes	100	50	0.79 a
Yes	50	100	0.66 a
Yes	50	50	0.53 a
No	0	100	0.63 a
No	0	50	0.40 a

Program Cost: The most expensive program was applying three full A506 applications and six full antibiotic treatments. The least expensive was using no A506 and only 66% of a full antibiotic program. Treatment IV, half A506 plus 66% of the full number of antibiotic sprays, cost $36 per acre, or 58% of the full program and only $7 more than a full stand-alone antibiotic program. It should be noted that though the no A506/full antibiotic is slightly more expensive, the repeated use of streptomycin increases the possibility of resistance, as was discovered to be the case in this orchard. Using A506 offsets this probability (Table 3).

Table 3: Comparative Cost of A506 (Blight Ban®) and Streptomycin (Agrimycin®) Treatments Used in 1999 – Wheatland, Yuba County

Treatment #	Rate		Cost/Acre		Total Cost	% of Treatment
	A506	Streptomycin	A506	Streptomycin		
I	Full	Full	$33.75	$29.00	$62.75	100%
II	Full	66%	$33.75	$19.33	$53.08	85%
III	Half	Full	$16.88	$29.00	$45.88	73%
IV	Half	66%	$16.88	$19.33	$36.21	58%
V	None	Full	$ 0.00	$29.00	$29.00	46%
VI	None	66%	$ 0.00	$19.33	$19.33	31%

Blight Ban®	$45.00 per 10.5 oz.	3 applications
Agrimycin®	$14.50 per lb.	4 & 6 applications
Size: 18 ac.		

CONCLUSIONS AND 2000 PLANS

The demonstration trial in 1999 confirmed that Pseudomonas florescens A506 (Blight Ban A506®) is capable of successfully colonizing and spreading through the orchard when applied at half the labeled rate under conditions suitable for colonization.

Plans in 2000 will be to apply A506 prior to bloom, then later in the spring to coincide with the onset of the early summer rat-tail bloom period. The pre-bloom timing has been shown to lead to colonization when combined with a silicon surfactant to enhance A506 penetration into the buds, thereby establishing this competitive bacterium in flowers as they emerge. This displaces other potential bud colonizing bacteria through the entire main bloom and petal fall period. The later A506 application(s) should then target any potential infections well after the main bloom period ends, allowing more accurate assessment of fire blight control.

ACKNOWLEDGEMENTS

The project leaders thank the cooperating grower, Joe Conant of Whitney Warren Ranch, for his support and assistance in carrying out the demonstration.

COMPARISON OF SEVERAL APPLICATION TIMINGS USING TEBUFENOZIDE (CONFIRM®), AN ECOYSONE AGONIST, FOR CONTROL OF OBLIQUE-BANDED LEAFROLLER

Report submitted for the Pear Pest Management Alliance

Project Leaders: Rachel Elkins, Robert Van Steenwyk and Mario Moratorio

Collaborators: Bill Oldham and John Sisevich

Research Assistants: Greg Balog, Sarah Davis and Jim Gonzales

ABSTRACT

Oblique-banded leafroller (OBLR) is the main secondary pest associated with codling moth (CM) mating disruption (MD) programs on the North Coast. There is no pheromone currently available for control by MD. The most effective chemical, encapsulated methyl parathion (i.e. Penncap M®) was cancelled on pears as of January 2000. The only remaining registered materials are BT (e.g. Dipel 2X) and chlorpyrofos (e.g. Lorsban®, pre-bloom only). The insect growth regulator tebufenozide (Confirm 2F®) will be registered for use in pears in 2000. Various application timings of Confirm® for control of OBLR were compared in two field trials in Lake and Mendocino Counties in 1999. Timings were based on the combined phenological stages of the tree (i.e. petal fall and "stop drop") and CM (2nd peak of the overwintering flight). In each trial, Confirm® treatments were compared to the grower standard of one Penncap M® applied to approximately coincide with the CM 1B peak. In Mendocino County, an additional follow up BT was also applied to the Penncap M® plots following observation by the PCA of OBLR larvae in new upper canopy shoot growth throughout the entire orchard. Insect activity was monitored by traps and degree-days (base 43°F/85°F). Larval stages and damage were sampled at least twice during the season. Results were similar in the two trials. In Lake County, the best control was from the petal fall plus 1B Confirm® treatments and the grower standard. In Mendocino County, the best control was also from the grower standard. Generally, one application of Penncap M® at 400-500 OBLR °D (with or without a supplemental BT) controlled OBLR through harvest and was equal to, or better than, two or three Confirm® applications applied either petal fall + 1B or 1B alone. Applications made at stop drop provided the least control. In all cases, the initial 1B Confirm® treatment required a follow up application due to short residual. These results indicate that Confirm® has a shorter control interval than Penncap M® and should be applied no sooner than when hatched OBLR larvae are visible, whether directed at the overwintering or summer generations. Sprays could be supplemented by one BT application after two or three weeks in order to kill escaped larvae.

PROCEDURE
I. Lake County

Location: Eutenier Home Orchard, north section, Kelseyville
12' x 12' spacing, 302 trees per acre

Trial Design: RCBD, three replications per treatment; each plot 5 rows wide, 35 trees long = 0.58 acres

Treatments

All timings were applied at 73 gpa by commercial concentrate air-blast spray rig. Tebufenozide treatments consisted of 18 oz. Confirm 2F® (Rohm and Haas) plus 5.8 oz. (0.0625% by volume) Latron B1956 (Rohm and Haas) spreader per acre. Treatment timings were:

1) Confirm 2F® at petal fall (May 1, °D = 116 CM, pre-biofix OBLR) and approximately codling moth (CM) 1B peak (June 11, °D = 512 CM, 300 OBLR), then three weeks later (July 7, °D = 957 CM, 911 OBLR).

2) Confirm 2F® at petal fall (May 1, °D = 116 CM, pre-biofix OBLR) and stop drop (July 31, °D = 1365 CM, 1474 OBLR).

3) Confirm 2F® at approximately CM 1B peak (June 11, °D = 512 CM, 300 OBLR), then three weeks later (July 7, ° = 957 CM, 911 OBLR) and stop drop (July 31, ° = 1365 CM, 1474 OBLR).

4) Grower standard = encapsulated methyl parathion (Penncap M®, Elf Atochem, 8 pints/acre), applied June 21 (°D = 677 CM, 531 OBLR).

Degree-days and trap catches (reference only)

OBLR degree-days (base 43° F/85° F, single sine horizontal cut off) were calculated from a UCIPM Pest Cast Campbell Scientific CR10X weather station located less than ¼ mile from the trial site. OBLR phenology was tracked using the Washington State University model. Trece OBLR (Western) traps were hung in the orchard prior to biofix to track OBLR flight.

Insect infestation

1) 500 eye-level clusters per treatment (166 per replication) were sampled on April 29 (pre-biofix and pre-treatment, overwintering larvae), June 30 (763 OBLR °D, 1st instar larvae of the first summer generation) and August 10 (1687 OBLR °D, late instar larvae of the first summer generation).

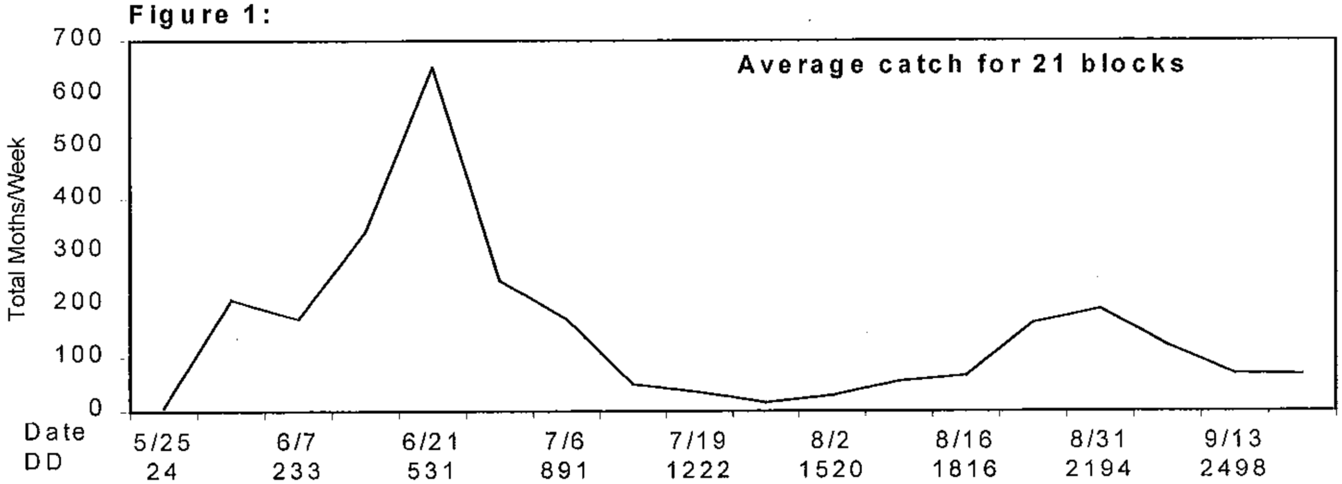
2) Bin counts were made at harvest, August 30-September 1 (2179-2209 OBLR °D, late instar larvae and pupae of first summer generation), 200 fruit/bin x 5 bins = 1000 fruit/replication.

RESULTS

Degree-day accumulation: OBLR biofix occurred May 25.

OBLR TRAP CATCH
Kelseyville, Lake County
May - September 1999

Figure 1:



DD = Degree Days   Biofix = 5/25/99

Trap catches: OBLR flight began May 25 and was heavy from June 1 through 21. Flight was low to moderate, though steady, from June 28 through September 13 (Figures 1 and 2, Table 1).

Table 1:

Kelseyville OBLR

WEEKLY PUFFER TRIAL UPDATE--OBLR TRAPS, TOTAL OBLRS CAUGHT																									
LOCATION	NUMBER OF TRAPS	DATE: wk. of	4/19	4/26	5/3	5/11	5/17	5/25	6/1	6/7	6/14	6/21	6/28	7/6	7/12	7/19	7/26	8/2	8/9	8/16	8/23	8/31	9/7	9/13	9/20
West Area--UPWIND																									
QUERCUS/HEDGEROW	4		*	*	*	*	0	1	6	4	27	49	51	35	10	5	4	6	3	6	17	22	21	5	4
RENFRO	2		*	*	*	*	0	0	1	1	14	16	6	6	5	1	1	1	2	0	12	10	3	2	5
MOSTIN	2		*	*	*	*	0	1	7	4	11	17	21	13	4	0	0	3	1	6	2	10	5	1	1
MORRISON	2		*	*	*	*	0	0	3	2	17	36	4	5	1	0	0	0	2	4	7	7	0	4	0
AKINS	3		*	*	*	*	0	0	10	8	9	68	8	1	3	0	0	0	1	11	9	7	0	0	2
PARDIE	3		*	*	*	*	0	2	30	33	32	80	12	10	2	1	1	0	3	5	18	10	10	7	5
MID AREA																									
ROHNER	3		*	*	*	*	0	0	4	8	35	38	25	18	2	3	1	3	10	3	10	3	5	0	10
COOKSON	8		*	*	*	*	0	0	5	16	32	72	17	17	2	1	0	0	1	0	1	9	8	1	5
M/TIMOTHY	2		*	*	*	*	0	0	14	12	17	21	18	0	0	0	0	0	0	0	0	1	1	0	3
S/TIMOTHY	4		*	*	*	*	0	0	7	12	30	31	11	6	8	1	0	0	0	0	3	1	4	0	4
M/TIMOTHY	6		*	*	*	*	0	0	10	5	33	33	13	9	0	2	0	2	1	0	4	8	19	8	2
STAGE	4		*	*	*	*	0	0	0	1	8	10	6	4	1	0	0	0	2	0	1	6	6	3	3
K48	10		*	*	*	*	0	1	1	4	9	8	3	8	0	0	1	1	3	6	15	19	9	10	0
MOSTIN/GOLE	7		*	*	*	*	0	0	3	12	28	32	26	9	6	0	1	0	4	2	5	14	9	12	8
WALNUTS			NO OBLR TRAPS																						
HOLDENRIED	5		*	*	*	*	0	0	3	3	21	38	11	7	0	0	1	1	0	2	2	3	4	10	1
EUTENIER	4		*	*	*	*	0	2	82	38	5	65	2	2	0	17	1	3	5	7	8	13	7	2	0
TRIANGLE	1		*	*	*	*	0	0	15	0	2	14	4	5	0	0	0	0	0	0	0	0	0	0	0
EAST AREA--DOWNWIND																									
TRAILERS	2		*	*	*	*	0	0	3	0	0	1	1	1	0	0	1	3	1	3	5	3	2	0	0
FOURTEEN	2		*	*	*	*	0	0	2	1	2	1	0	0	1	2	0	0	0	0	9	2	0	0	3
SIXTY	10		*	*	*	*	0	0	3	7	6	10	4	6	5	2	4	5	8	7	18	26	8	1	8
YOUNG WEST	10		*	*	*	*	0	0	0	2	1	11	2	11	0	0	0	1	8	4	19	17	2	4	4
GROWER CONTROLS																									
HANSON	2		NO OBLR TRAPS																						
SPRINGER	2		No traps						1	1	7	6	4	9	0	0	1	1	0	10	11	4	0	0	0
UNTREATED CONTROLS																									
QUERCUS/SEVEN ACRE	1		No traps					0	2	7	15	7	30	14	10	3	4	1	6	0	18	4	1	0	2
STAGE	1		No traps					0	8	5	8	25	3	0	0	0	0	0	0	1	3	1	1	0	0
GOLD DUST	1		No traps																						

* OBLR traps not hung.

OBLR traps hung the week of May 17.

Larval presence and damage: First summer generation larvae were apparent on June 30 (763 OBLR °D). This was 19 days after the June 11 and seven days prior to the July 7 tebufenozide treatment, but only nine days after the June 21 Penncap M® treatment. Mature larvae were present at the August 10 sampling. Both mature larvae and pupae, though no 2nd summer generation larvae, were found in the bin sample August 30-September 1. Damage was found in the August 10 sample and in bins at harvest. 8.4% of the damage in bins was from overwintering versus 91.6% from first summer generation larval feeding.

Table 2: OBLR Infestation and Damage – Eutenier Orchard, Kelseyville, 1999

Treatment	Sample Date				
	4/29 no. larvae (pre-treat)	6/30 no. larvae	8/10 no. larvae	% damage	8/30-9/1 % damage
Petal fall + 1B	**1**	**1.3**	**0**	**3.0**	**1.9 A**
Petal fall + stop drop	**0**	**1.0**	**0**	**3.2**	**3.1 B**
1B + stop drop	**0**	**1.7**	**0.3**	**7.0**	**4.25 B**
Grower standard (1B only)	**1**	**1.0**	**0**	**0.0**	**1.2 A**
	NS	**NS**	**NS**	**NS**	*
*** = significant at p=0.10**				**(P=0.13)**	**(P=0.07)**

Table 3: Proportion of Damage in Bins Due to Overwintering and Summer Feeding Eutenier Home Orchard, Kelseyville, Lake County, August 30-September 1, 1999

Treatment	Proportional % of Damage	
	early	late
Petal fall + 1B	**7.9**	**92.1**
Petal fall + stop drop	**7.8**	**92.2**
1B + stop drop (1 rep only)	**1.9**	**98.1**
Grower standard	**28.0**	**72.0**

Damage was least in the petal fall plus 1B Confirm® plots and in the grower standard of Penncap M® applied once on June 21. The stop drop timings were the least effective. The petal fall timing may have reduced early season larvae, however, lack of replicated data (especially for petal fall + stop drop) precludes positive conclusions. Harvest data indicates that damage caused by early season larvae is a minor component of total damage at harvest (Table 2; Table 3, non-analyzed).

II. Mendocino County

Location: Ashurst Orchard, Hopland, California
North block: 22' x 22' spacing, 90 trees/acre
South block: 20' x 20' spacing, 109 trees/acre

Trial Design: Two non-replicated plots about two acres each, with three sub-samples per plot:
North plot: 5.8 rows wide x 31 trees long
South plot: 5.6 rows wide x 39 trees long

Treatments

All treatments were applied at 250 gpa by commercial air-blast spray rig. All tebufenozide treatments consisted of 18 oz. Confirm 2F® plus 8 oz. (0.0625% by volume) Latron B1956 spreader per acre. Treatment timings were:

1) Confirm 2F® at approximately CM 1B peak (June 14, °D = 675 CM, 404 OBLR), then three weeks later on July 14 (°D = 1284 CM, 1185 OBLR).

2) Grower standard = encapsulated methyl parathion (Penncap M®, 4 pints per acre) at CM 1B peak (June 14, °D = 675 CM, 404 OBLR). Followed by BT (Dipel 2X, 2 lbs. per acre) plus 3 gal. 415 oil (July 15-17, °D = 1300 CM, 1185 OBLR) following observations of OBLR larvae in top shoots throughout the entire orchard.

Degree-days and trap catches: OBLR degree-days (base 43°F/85°F, single sine horizontal cutoff) were calculated from a UCIPM Adcon Telemetry weather station located near the trial site. Wing traps with Trece OBLR (Western) lures were hung in the orchard prior to biofix to track OBLR flight.

Insect infestation: 1,000 eye level fruit per treatment (166 per sub-plot treatment) were sampled prior to treatment on June 10 and then for larvae of the first summer generation on July 7 (984 OBLR °D) and August 10 (1820 OBLR °D). No sampling was done at harvest.

RESULTS

Degree-day accumulation: OBLR biofix occurred May 25.

Trap catches: Moths were caught in PCA traps only on May 26 (20 moths) and June 2 (1 moth, 507 OBLR °D). Trap monitoring ended after June 30.

Larval presence and damage occurrence: There were an average of four OBLR in the south Confirm® plots and three OBLR in the south Penncap M® plots on June 10, prior to treatment. There were no OBLR found in the north plots on that date. On July 7, an average of 4.65 worms were counted in the Confirm® plots, versus 0.35 in the Penncap M® plots. On August 10, the number of worms had increased to an average of 22.35 in the Confirm® plots, versus 2.0 in the Penncap M® plots. Damage data is lacking for this sample date (Table 4).

Table 4: OBLR Presence and Damage
Ashurst Orchard, Hopland, Mendocino County - 1999

	No. worms				No. damaged			
Location	Penncap M®		Confirm®		Penncap M®		Confirm®	
	7/7	8/10[1]	7/7	8/10	7/7	8/10	7/7	8/10
North	0.7	2.0	4.3	18.0	1.3	--	9.3	--
South	0.0	2.0	5.0	26.7	0.0	--	9.3	--
Average	0.35	2.0	4.65	22.35	0.65	--	9.3	--

[1] 2 lbs. BT + 3 gals. 415 oil per acre applied July 15-17

CONCLUSIONS

OBLR trap catch data is useful for establishing biofix and determining when larvae may begin to be more easily seen in the clusters. Though catches often fail to correlate with presence or absence of damage, in comparing the Lake County Eutenier trap catches with others in the same vicinity, orchards with chronically very high catches appear to sustain some level of damage if treatments are forgone.

OBLR larvae appear to first be readily seen at about 600-700 OBLR °D, or shortly after the main portion of the overwintering flight ends. Overlap with the CM 1B flight will vary year to year; in Lake County in 1999, larval hatch corresponded with about 800 CM °D, the last half of the 1B peak. Larval emergence continues for at least several weeks, thus a long-residual treatment applied at or shortly before this time, e.g. Penncap M® in this case, appears to be effective in controlling late-season damage. Shorter residual materials such as Confirm®, however, will require a second treatment to cover the entire hatch, especially if applied early, as was done in both trials.

OBLR damage at harvest was least in the grower standard in both trials. In Lake County, as stated above, this treatment was applied closest to the first observed larvae of the summer generation. This one application provided the same or better control than three applications of tebufenozide applied at petal fall, early June and early July, though the proportion of early season damage was higher in the Penncap M® plots, presumably due to lack of pre-bloom or petal fall control. Also, the longer residual of Penncap M® allows for a wider window of control. This factor was corroborated in the Mendocino trial, where Penncap M® and Confirm® were both applied at 404 °D OBLR; the Confirm® plots required a second spray after three weeks, yet still sustained high damage, even though the Penncap M® rate was half that applied in Lake County.

It is possible that had the Confirm® been applied when larvae were first visible, results at harvest would have been better. This was the case in a 1998 Lake County trial in which Confirm® applied prior to 500 OBLR °D failed to improve control by pre-bloom chlorpyrifos (Lorsban®) alone, but when also applied at 700 OBLR °D, reduced damage by 66% (though control by organophosphates was even better). This indicates that Confirm® may lack the residual to bracket the entire larval hatch and thus has more exacting timing requirements, especially where OBLR populations are high (Table 5).

Data from a trial conducted by Lucia Varela in Mendocino County in 1998 showed four applications of Confirm®, two at petal fall and two applied to the summer generation, were less effective than Penncap M® applied twice early in the season (Table 6).

Penncap M®has been cancelled on pears as of 2000. Based on the data from 1999, as well as previous years, trials in 2000 should compare applications of spinosad (Success®, Dow Elanco) and tebufenozide (Confirm®) timed at petal fall and/or approximately 600-700 OBLR °D to verify 1998 and 1999 results. This will confirm whether the IGRs, if timed properly, can control OBLR at harvest with only one or two, well-timed applications. Supplementing the summer application with one follow up BT after two weeks may also be a viable option.

Table 5: 2ND GENERATION OBLR DAMAGE
Bartlett pears, Lake County, September 1998
Bin Counts (% / 1000 fruit)

PLOT	PUFFER+LORSBAN			PUFFER+LORSBAN+ CONFIRM 400°D			PUFFER+LORSBAN + CONFIRM 400&700°D			PUFFER+OP		
	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total
PUFFER												
S. Timothy	0.5	0.9	1.4				0.8	0.4	1.2	0.2	0.0	0.2
M. Timothy										1.0	0.0	1.0
Y. Cookson	0.0	1.4	1.4	0.0	0.7	0.7	0.0	1.1	1.1	0.0	0.7	0.7
E. Home	2.6	6.4	9.0	5.0	5.4	10.4	1.3	1.6	2.9	0.1	1.2	1.3
H. Sanderson	0.0	2.4	2.4	0.0	2.1	2.1	0.0	0.7	0.7	0.0	1.7	1.7
AVERAGE	0.8	2.8	3.6	1.7	2.7	4.4	0.5	1.0	1.5	0.3	0.7	1.0
GROWER (OP only)										0.0	0.3	0.3
UNTREATED												
Q. Keithly										0.0	3.0	3.0
Y. Stage										4.0	3.4	7.4
AVERAGE										1.3	3.2	5.2
Source: R. Elkins, 1998 Pear Research Reports, p. 77-85.												

Table 6: Control of Oblique-banded Leafroller with Confirm® and Penncap M® at Talmage Orchard, Ukiah, Mendocino County, 1998

DATE	CONFIRM®		PENNCAP M®	
	Mean % Alive OBLR	Mean % Damage Fruit	Mean % Alive OBLR	Mean % Damage Fruit
27 March	0.0	--	0.0	--
10 April	0.5	--	0.5	--
17 April	1.5	--	1.5	--
24 April	1.0	--	1.0	--
15 June	0.0	--	0.0	--
26 June	3.7	--	0.0	--
30 June	1.0	--	0.0	--
13 July	1.3	1.1	0.1	0.0
27 July	0.0	2.3	0.0	0.0
26 August	0.5	--	0.1	--
Source: R. VanSteenwyk and L. Varela, 1998 Pear Research Reports, p. 61-74				

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Evaluation of New Insecticides for True Bug Control

Prepared for the California Department of Pesticide Regulation's Pear Pest Management Alliance and the California Pear Advisory Board – 1999 Season

R. A. Van Steenwyk & S.C. Welter
Dept. E.S.P.M.
University of California
Berkeley, CA. 94720

ABSTRACT:
True bugs were not considered to be major pear pests in the past. However, recent changes in the codling moth (CM) management strategy have resulted in increased damage by true bugs. True bugs are often controlled indirectly by organophosphate or carbamate (OP/CARB) insecticides that are applied for CM control. The pheromone mating disruption programs for CM has been successfully suppressed with pheromone mating disruption, and consequently OP/CARB use was reduced by about 75%. Unfortunately, the reduced usage of OP/CARB insecticides resulted in a substantial increase in true bug damage compared to damage observed at conventional sites. In fact, damage was greater from the true bugs than from CM. If outbreaks of true bugs occur in mating disrupted orchards and require OP/CARB insecticide applications for their control, then the value of the IPM program that reduces OP/CARB use will be threatened. New true bug insecticides, which are effective, environmentally benign, biologically selective and exhibit low mammalian toxicity must be found and registered in order to reap the ecological benefits of the pheromone based CM management strategy.

A number of insecticides were evaluated both in the laboratory and field for true bug control. The pyrethroid insecticides (Asana, Danitol, Brigade, etc) provided excellent and over an extended period of time control. However, their use would be very disruptive to the pear ecosystem. The most promising new insecticide for true bug control is Provado. Provado is registered for use on pears. Research next year will concentrate on Provado and other nicotinoid insecticides that are being developed by various agricultural chemical manufacturers.

INTRODUCTION:
True bugs [Lygus hesperus Knight (western tarnished plant bug), L. elisis Van Duzee (pale legume plant bug), Euschistus conspersus (consperse stink bug), Thyanta accerra McAtee (redshouldered stink bug), Acrosternum hilare (Say) (green stink bug), Boisea trivittata (Say) (boxelder bug) and others] were not considered to be major pear pests in the past. However, recent changes in the CM management strategy have resulted in increased damage by true bugs. True bugs do not develop in pears and nymphs are seldom found in pear trees. However, adults migrate from neighboring areas or orchard weeds and feed on the developing fruit. Adult feeding causes eruptions, lesions or dimples on the fruit. This feeding, if severe, makes the pears unmarketable for either fresh market or cannery sale. True bugs are often controlled indirectly by OP/CARB insecticides that are applied for CM control. The pheromone mating disruption programs for CM in pome fruits in California and the western US (currently over 55,000 acres) have significantly reduced the usage of OP/CARB insecticides. In the Randall Island and

Mendocino Pear Projects, CM was successfully suppressed with pheromone mating disruption, and consequently OP/CARB use was reduced by about 75%. Unfortunately, the reduced usage of OP/CARB insecticides resulted in a substantial increase in true bug damage compared to damage observed at conventional sites. In fact, damage was greater from the true bugs than from CM. Therefore, the changing face of IPM in pears has made the need to control true bug species with selective insecticides all the more important. If outbreaks of true bugs occur in mating disrupted orchards and require OP/CARB insecticide applications for their control, then the value of the IPM program that reduces OP/CARB use so extensively will be threatened. In addition, the implementation of the Food Quality Protection Act may significantly reduce or eliminate most OP/CARB insecticides. New true bug insecticides which are effective, environmentally benign, biologically selective and exhibit low mammalian toxicity must be found and registered in the near future in order to reap the ecological benefits of the pheromone based CM management strategy. Reported here are the results of our laboratory and field insecticide evaluations for true bugs.

1. Laboratory Bioassays of New Insecticides for Lygus and Stink Bug Control

Methods and Materials: Plastic zip-lock bags (2 to 3 in.) were treated with 10 μL of pesticide diluted in acetone. The pesticide was allowed to dry. Fourteen adult female lygus bugs (LB) were placed in a plastic zip-lock bag with two small pinto beans. The pinto beans act as spacers. Two bags of each concentration were used for analysis. The bags were held at 73-77°F and mortality was determined after 24 hours. Each potential true bug insecticide was first screened over a wide range on concentrations. The plastic bags were treated with a series of concentrations from 0.1 to 100 times the field rate. If the preliminary LC_{50} was greater than 50 times the field rate, then there were no further laboratory evaluations of the material. If a material showed some promise, then the plastic bags were treated with a series of five to six concentrations of the insecticide. The concentrations of the insecticide were within the expected LC_{10} to LC_{90} range.

Thirteen adult male green stink bugs (GSB) were placed with their dorsal side on a sticky surface. A dilution series of the potential insecticide was made in acetone. Each adult GSB was treated on the ventral surface of the abdomen with 3μl of pesticide solution using a microsyringe. The GSB were held at 80°F in a growth chamber and mortality was determined after 24 hours.

Results and Discussion: Eight insecticides were screened for LB efficacy. Two insecticides, Alert SC (Chlorfenapyr) and Success 2SC (Spinosad) had LC_{50} values greater than 50 times the field rate. Further laboratory evaluations of these two insecticides were not preformed. Probit analysis of the dose mortality data from the remaining six insecticides indicates that Dimethoate has a LC_{50} value of less than one times of the field rate (Table 1). However, the LC_{50} values of Brigade and Asana were much greater than one times the field rate. Only Provado had a LC_{50} value similar to Dimethoate. Since Asana provided excellent control in our field trials (see below), it appears that the bag bioassay method may not be an appropriate method of estimate field efficacy for LB control. Further research will be conducted to develop an appropriate laboratory screening bioassay method for LB. These results may be explained based on the temperature in which the LB were held in the bioassays. The field trials indicated that Asana mortality was temperature dependent. The laboratory bioassays were conducted at 77°F or less which might explain the lower than expected mortality. It is also possible that confining the LB in the plastic bag increased the fuming action of Dimethoate and improved the efficacy of Dimethoate. The direct topical applications of Dimethoate and Asana on adult GSB produced a

LD_{50} at 0.1 times of field rate for Dimethoate and a LD_{50} at 1 times the field rate for Asana (Table 2). Again these results are not what would be expected based on our field trials. Further research will be conducted next year to improve the bioassay.

Table 1. Laboratory Bioassays for Lygus Bug Control Using Various Potential Insecticides

Trade Name	Rate g (ai)/L	Field Rate amount/100 gal.	LC_{50} (95% CL) g (ai)/L	LC_{50} (95% CL) n x field rate
Dimethoate E267	2.4	6.0 pt	1.7 (1.4-1.9)	0.7 (0.6-0.8)
Brigade 10 WP	0.12	1.0 lb	0.9 (0.7-1.0)	7.1 (5.8-8.1)
Asana 0.66EC	0.09	14.5 oz	0.6 (0.5-0.8)	6.6 (5.3-8.6)
Asana 0.66EC	0.09	14.5 oz	0.4 (0.3-0.5)	4.7 (3.5-5.8)
Pounce 3.2 EC	0.48	16.0 oz	5.2 (3.6-12.8)	10.8 (7.4-26.6)
Pounce 3.2 EC	0.48	16.0 oz	3.3 (2.4-4.8)	7.0 (5.1-9.9)
Pounce 3.2 EC	0.48	16.0 oz	3.5 (1.7-4.6)	7.3 (3.5-9.6)
Provado 1.6F	0.3	20.0 oz	0.4 (0.2-0.5)	1.2 (0.7-1.7)
Actara 25WG	0.09	0.3 lb	0.6 (0.4-0.8)	6.4 (4.3-8.5)

Table 2. Laboratory Bioassays for Green Stink Bug Control Using Various Potential Insecticides

Trade Name	Rate g (ai)/L	Field Rate amount/100 gal.	LD_{50} (95% CL) g (ai)/L	LD_{50} (95% CL) n x field rate
Dimethoate E267	2.4	6.0 pt	1.0 (0.1-0.5)	0.1 (0.1-0.2)
Asana 0.66EC	0.09	14.5 oz	0.1 (0.1-0.2)	1.0 (0.7-1.6)

2. Field Evaluations of New Insecticides for Lygus and Stink Bug Control

METHODS AND MATERIALS:

Two trials were conducted on mature 'Bartlett' pear trees in a commercial orchard near Hood, CA. Trial A consisted of five treatments and trial B consisted of eight treatments. Each treatment was replicated four times in a randomized complete block design. Each replicate consisted of an individual tree and there was a buffer tree in each direction from the treated tree. Treatments were applied between 6:00 a.m. to 9:00 a.m. on 7

June for trial A and 12 July for trial B with a hand-held orchard sprayer operating at 200 psi and delivering 400 gal/acre of finished spray (1.33 gal/tree). Control in trial A was evaluated by caging 20 adult LB on the foliage for 12 hours (6:00 p.m. to 6:00 a.m.) at 0, 3, 7 and 14 days after treatment (DAT). Control in trial B was evaluated by caging 20 adult LB and 20 adult GSB in separate cages for selected treatments on the foliage for 12 hours (6:00 p.m. to 6:00 a.m.) at 0, 3, 7 and 14 DAT.

RESULTS AND DISCUSSION:

All insecticide treatments provided significantly LB and GSB mortality compared to the untreated control on the day of application in both trials (Table 3). In trial A, Asana and Provado and in trial B, Danitol, both rates of Asana and the two high rates of Provado provided excellent LB control while only Danitol and Asana provided excellent GSB control. At 3 DAT in trial A, all insecticide treatments provided significantly greater LB mortality as compared to the untreated control. In trial B, Danitol, both rates of Asana and the high rate of Provado provided significantly greater LB mortality compared to the untreated control with only the high rate of Asana providing excellent LB control. Danitol and Asana provided significant control of GSB but neither provided excellent control. Similar results were observed at 7 DAT except no treatment provided excellent control. However, at 14 DAT in trial B, mortality was greatly increased as compared to 7 DAT. Both rates of Asana for LB and Danitol for GSB provided greatly improved control. This increase in mortality was likely the result of higher temperatures. The maximum air temperature at 7 DAT was 75°F in trial B while the maximum air temperature at 14 DAT was 85°F. An increase in temperature appears to increase greatly the efficacy of both Asana and Danitol.

Table 3. Mean Percent Mortality of Caged Lygus and Green Stink Bugs at Hood, CA - 1999

		Mean[a] Percent Mortality DAT							
	Rate	0		3		7		14	
Treatment	lb (AI)/ac	LB	GSB	LB	GSB	LB	GSB	LB	GSB
		Trial A							
1. Dimethoate E267	2.000	59 c	----	50 b	----	19 b	----	16 a	----
2. Asana XL	0.072	80 d	----	89 c	----	45 c	----	76 b	----
3. Provado 1.6F	0.250	74 d	----	54 b	----	40 c	----	23 a	----
4. Actara 25 WG	0.063	50 b	----	46 b	----	23 bc	----	18 a	----
5. Untreated	----	17 a	----	17 a	----	5 a	----	15 a	----
		Trial B							
1. Alert 2SC	0.313	59 c	----	23ab	----	13 a	----	43 ab	----
2. Asana XL	0.041	97 e	----	35 bc	----	19 ab	----	87 cd	----
3. Asana XL	0.072	100 e	97 c	91 e	29 b	31 bc	39 bc	90 d	51 b
4. Danitol 2.4 EC	0.394	96 e	98 c	61 d	38 b	43 c	59 c	59 bc	83 b
5. Provado 1.6F	0.063	48 b	----	9 a	----	8 a	----	34 ab	----
6. Provado 1.6F	0.125	80 d	----	22 ab	----	17 ab	----	28 a	----
7. Provado 1.6F	0.250	81 d	52 b	45 cd	13 a	8 a	15 ab	36 ab	20 a
8. Untreated	—	17 a	6 a	9 a	5 a	7 a	4 a	16 a	1 a

[a]Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$). Data analyzed using an arcsin transformation.

CONCLUSION:
This study was a rigorous evaluation of the insecticide treatments since the LB and GSB were confined on the foliage for only 12 hour during the night. Confining LB for 24 hours or more would likely increase the efficacy of the insecticides (see Evaluation of Lygus Control at Various Periods of Foliar Exposure). However, high control mortality would be expected when confining LB for 24 hours or more with temperatures exceeding 90°F. All experimental treatments provided a significantly higher mortality than the untreated control on the day of treatment. However, Alert and the lower two rates of Provado 1.6F were not significantly different than the untreated control at 3, 7 and 14 DAT. Danitol and the high rate of Asana XL were the only treatments with significantly greater mortality as compared to the untreated control at every evaluation period and their effectiveness appears to be temperature dependent. The most

promising new chemistry for true bug control is Provado. Research next year will concentrate on Provado and other nicotinoid insecticides that are being developed by various agricultural chemical manufacturers.

3. Lygus Bug Control at Various Periods of Foliar Exposure
Methods and Materials: A trial was conducted on mature 'Bartlett' pear trees in a commercial orchard near Fairfield, CA. Three treatments were replicated four times in a randomized complete block design. Each replicate consisted of an individual tree. Treatments were applied on 8 August between 6:00 a.m. to 9:00 a.m. with a hand-held orchard sprayer operating at 250 psi and delivering 200 gal/acre of finished spray (2.87 gal/tree). Control was evaluated by caging 20 adult LB on the foliage for 12, 24, and 48 hours starting at 6:00 p.m. on the day of treatment.

RESULTS AND DISCUSSION:
When LB were confined on the foliage for 12 hours, control was poor with either Dimethoate or Provado (Table 4). When LB were confined on the foliage for 24 hours, mortality of both Dimethoate and Provado increased without corresponding increase in the mortality in the untreated control. When the LB were confined on the foliage for 48 hours, control increased to an acceptable level with either Dimethoate or Provado. However, the mortality in the untreated control was approaching 25%, which is unacceptable. When corrected for untreated control mortality, the Dimethoate mortality increased substantially from 12 to 24 hours of confinement and then remained about the same for 48 hours of confinement while Provado mortality increased with length of time of LB confinement. Unfortunately, this study was conducted with moderate maximum air temperatures and control mortality could not be determined at high (90°F) maximum air temperatures.

Table 4. Mean Percent Mortality of Caged Lygus Bugs for Various Period After Treatment at Fairfield, CA. - 1999

		Mean[a] Percent (Corrected) Mortality at Hours after Treatment					
Treatment	Rate lb (AI)/ac	12		24		48	
1) Provado 1.6F	0.075	44 ab	(32 a)	61 b	(52 a)	88 b	(85 a)
2) Dimethoate	1.340	53 b	(40 a)	79 b	(74 a)	81 b	(75 a)
3) Untreated	—	17 a	----	19 a	----	23 a	----

[a]Means followed by the same letter within a column are not significantly different (Fisher's protected LSD, $P \leq 0.05$). Data analyzed using an arcsin transformation.

CONCLUSIONS:

LB mortality increased with the time that the bugs were confined on foliage treated with either Dimethoate or Provado. The effect was more pronounced with Provado than Dimethoate. When moderate temperatures are predicted (max. air of about 75°F), it appears that LB can be confined for 24 hours on foliage without unacceptable control mortality.

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